

REGIONAL ECONOMETRIC MODELS FOR TASMANIA

Submitted as a thesis
for the degree of
Master of Economics.

W. L. Wong
May, 1974.

CONTENTS

	Page
ABSTRACT	iii.
CHAPTER	
1 Introduction	1
2 Uses and Types of Regional Econometric Models	13
3 A General Account of Existing Regional Econometric Models	39
4 A Feasibility Study of the Tasmanian Economy	89
5 Estimation of Gross State Product for Tasmania	123
6 A Regional Empirical Model for Tasmania	151
7 Regional Economic Base Models for Tasmania	181
8 Forecasting Performance of the Tasmanian Regional Empirical Model	211
9 Conclusion	241
APPENDIX Data Tables and Statistical Sources	247
BIBLIOGRAPHY	263

ABSTRACT

In recent years one can detect an increasing use of econometric models for the analysis of national economies. For regional economies, however, the art of econometric model-building has not been fully exploited and the application of econometric models to regional analysis has not been widespread. Only a small number of regional econometric models can be found in the literature and these have been produced mainly in the U.S. So far as can be determined, no econometric model has yet been constructed for an Australian region and our study appears to be the first of its type so far undertaken in this country.

The purpose of the study is to record experience in the development of regional econometric models for Tasmania. After a brief introductory chapter, two chapters are devoted to a review of the regional econometric models to be found in the literature. These chapters set the stage for the development of regional econometric models for Tasmania. A feasibility study is then undertaken in Chapter Four. Here we compare the data required for the construction of a particular type of regional econometric model with the available Tasmanian statistics with a view to deciding on the types of regional econometric models which are feasible for Tasmania at the present time. We then proceed to construct two types of regional econometric models which we call a regional economic base model and a regional empirical model. This is done in Chapters Six and Seven respectively.

The regional economic base model is used to compute regional multipliers for Tasmania as well as for the study of growth while the regional empirical model is used to forecast three Tasmanian aggregates: gross state product, total personal income, and total employment.

The forecasting performance of our regional empirical model is then evaluated by comparing forecasts generated by this model with forecasts generated by two "intrinsic" models using Theil's U statistic as a measure of forecast accuracy. It was found that our regional empirical model performed better than the two intrinsic models.

CHAPTER ONE
INTRODUCTION

During the past two decades or so econometric models have been used extensively for the analysis of national economies. Their usefulness in the formulation of economic policies, in economic planning, and in forecasting, has been widely recognized and they have become a popular tool in national economic analysis. At the sub-national level, however, econometric models have still to make their mark. While their use in regional economic analysis has increased significantly in recent years it remains true that their potential in this area has by no means been fully realised.

Studies of the economy and the economic problems of a particular region have been undertaken in many countries, with the United States very decidedly in the lead so far as the volume and the variety of the work are concerned. In Australia, however, model-building at the regional level is still an undeveloped area. As far as we know our study is the first attempt to develop a regional econometric model in Australia and, as such, can be viewed, therefore, as a feasibility study for this type of econometric work in this country.

An important aim of the study is to consider overseas work relating to regional econometric models (REM). This will enable us to place the task of constructing REM for Tasmania in perspective and will suggest approaches that might be applied in future to other similar studies. The first three chapters of our thesis are devoted to this discussion of overseas work.

1.1 Model Building at the Regional Level

Before we discuss the philosophical issues involved in model-building at the regional level we will first define the terms "econometric model" and "region" which will be used widely in this study. An econometric model we define broadly as any economic model the parameters of which have been estimated from past observations on the variables of the model. On this broad definition, REM include input-output models, economic-base models, and some macroeconomic regression models using time series data, when they are applied to the study of a particular region. A region, on the other hand, is defined in this study as any part of a wider geographical area within which free trade prevails, and within which movements of labour and capital are not subject to control. Thus a region in this study might include the geographical area of a state, a county, a metropolitan area, and even the territorial area of a country.

The design of an econometric model has been characterized as "a series of compromises among: (a) the structures of the economy to be described; (b) the multiple, and often partially conflicting objectives of the model..... and; (c) the availability of data..... it is an unfortunate fact of life that the last of the three tends to dominate."¹

The "state of the art" in regional analysis has reached the point where there are several conceptual structures for a regional econometric model. These structures can be conveniently grouped into two main classes. The first class contains models that bear a close

1. M. Nerlove, "A Quarterly Econometric Model for the United Kingdom", American Economic Review, Vol. LII, No.1 (March 1962), p.156.

resemblance to the models commonly used at the national level; indeed some are nothing more than national models with a slight regional twist. Examples of this class include national-income determination models of the Keynesian type which emphasize aggregate demand and its components, the national growth models of the Solow-Swan type which emphasize savings, capital formation, and technical progress as the main determinants of growth. (See Section 3.3.2 and 3.3.3 in Chapter Three below). Proponents of models of the Keynesian-type suggest that the process of regional-income determination follows much the same lines as those depicted in national income analysis and hence that the Keynesian type of model structure is adequate for regional analysis.² There must, of course, be a shift in emphasis in REM in that more attention is to be placed on interregional flow relationships so as to account for the fact that regional economies are characterized by a much higher degree of "openness" than the national economies. Therefore, relationships regarding interregional trading, migration, investment, and other interregional movements of goods and services are of paramount importance in this type of REM. But, on the whole, the proponents of the Keynesian-type of model structure argue that this type of structure is adequate for the analysis of regional income and its determination. In a similar fashion, proponents of the Solow-Swan type of model structure for the study of regional growth suggest that the study of regional economic growth can be handled by this type of model structure in much the same way as in the study of national economic growth, their reasons being that regional economic growth

2. See, for example, L.R. Klein, "The Specification of Regional Econometric Models", Papers and Proceedings of the Regional Science Association, Vol. 23, 1969.

often takes place within the region itself and is due to such factors as increasing amount of regional savings, regional capital formation, and technical progress which has been transmitted into the region.³

On the other hand, there is another group of regional researchers who are simply not convinced that REM should be merely micro replicas of national models. Instead they adopt model structures which are quite different from the commonly used national econometric models (NEM) and which have special features of their own. These fall into two classes. The first class has adopted economic-base theory and location theory (instead of the Keynesian theory or the Solow-Swan version of the neoclassical growth theory) to explain and predict both the processes of regional income generation and of regional growth. Economic-base theory rests on the hypothesis that income generation and growth in a region is initiated and sustained by the "basic" industries which comprise the export sector of the region concerned, while the remaining "service" industries follow the movements of the basic industries. The concept involved is a Keynesian-type income multiplier analysis with the dominant role played by the export sector which is considered as exogenous in the analysis, and with the non-exporting sector considered as endogenous. Location theory was originally put forward to explain the factors determining the growth of a particular firm or even an industry and was later extended to explain the growth process of a whole regional economy. Both

3. See, for example, F.W. Bell, "An Econometric Forecasting Model for a Region", Journal of Regional Science, Vol. 7, 1967.

the economic base theory and the location theory have been widely criticised on the ground that both have taken a too narrow and simplistic view of the actual process of regional income generation and of regional growth and a more convincing regional theory of both processes has yet to emerge.⁴

The second class takes the form of a regional empirical model which consists of a series of regression equations in which regional variables are related to national variables. They are convenient forecasting devices, but unfortunately they lack a good theoretical backbone and tell us virtually nothing about the working of the regional economy itself. They have, however, one big advantage over the other class of structure for a REM, namely that by emphasizing the use of national variables instead of regional variables, they minimize the use of regional data which are in most cases hard to come by.

The second of the three elements in the design of an econometric model are the objectives of the model. In the past the main users of regional econometric models have been regional policy-makers. For this reason, the relevant constraints in a REM should specify both the objectives of the regional policymaker in question and the tools which are available to him. In these respects REM are quite different from NEM. NEM have been developed to encompass the economic aspects of all policies carried out by the federal government

4. Both the economic base theory and the location theory will be discussed in more detail in Chapters Two and Three below. For further discussions on them, see H.W. Richardson, "Regional Economics", Weidenfeld and Nicolson, London 1969, Chapter 10.

and its agencies. Many of these, like defence or foreign policy, are not tackled below the national level. Until recently the cyclical stability of the national economy has been the main focus of attention. Such problems as growth, equalization of differences in development between various parts of the nation, and distribution of wealth and income have only received minor attention. At the regional level, on the other hand, considerations of growth, welfare, and provision of various amenities and services are paramount.

Differences in the tools are equally pronounced. The national government can make use of various powerful tools of fiscal, monetary, and commercial policy such as taxation, supply of money, measures influencing the interest rate, import duties or even import quotas, exchange controls, and so on. At the sub-national level, on the other hand, even in the case of regions corresponding to states, the tools at the disposal of the regional government are relatively modest, both because of the political limitations of the government and, more importantly, because basic national economic measures cannot usually be adapted to the needs of a single region. A significant limitation, for example, stems from the inability of regional governments to control the movements of factors of production over their boundaries by placing restrictions on migrations or interregional money flows. This is further aggravated by their inability to control exports and imports, money supply, and the general economic climate which essentially depend on national development. The result is that policies affecting regional economic growth and welfare may come from any level of government. REM can

be used to gauge the regional impact of such policies, especially from those of the national government, and in order to do this a regional model should include a different set of goals and policy instruments from the set which is commonly found in national models.

The third element in the design of an econometric model is data availability. Once data has been applied to the implementation of an econometric model economic theory can be tested against real world situations, thus data serves to bridge the gap between theory and reality. For NEM, a set of national social accounts provides the main data base. Correspondingly a set of regional accounts will go a long way towards providing a useful data base for a REM. These accounts yield valuable information on the economic performance of geographical regions and the internal workings of a regional economy. In particular a balance of payments or flow-of-funds schedule yields useful data on a region's trade position, its economic ties with other areas, and the transmission of capital between regions. However, whereas a set of national accounts is available for most national studies, the need for a complete set of regional accounts for regional economic analysis remains, in most cases, unsatisfied. Indeed, the usual situation is that only a few regional economic variables have been measured on a regular basis, and these for no more than a comparatively short span of time. Regional data requirements remain the most serious constraint in the design of REM.

1.2 The State of Tasmania as the Regional Unit

The region under analysis in this study is the State of Tasmania. If a "region" is taken to mean a particular geographic area, then because it is an island, Tasmania is a clearly defined region. On the other hand, Tasmania also represents a well-defined "political" region since it is one of the six States of the Australian federation. A third interpretation - an "administrative" region - can also be given to the State of Tasmania since the role of the Tasmanian Government in the administration of Tasmania is clearly written into the Australian Constitution.

As compared to the mainland States of Australia, it appears that Tasmania has certain advantages as a study-region. Being an island-economy and geographically isolated from the rest of the country, it has better statistics on the inter-state movement of both goods and people than the mainland States. As mentioned in the last section, data availability is a critical factor in the design of REM and paucity of data relating to interregional flows is usually a most serious problem. In the case of Tasmania, the task of tracing inter-state movements of both goods and factors of production is much easier than it is for the five mainland States. For the mainland States, inter-state movements of both goods and people can be handled by air, sea and land transport. Inter-state movements by land transport however, are not subject to administrative control and statistics for such movements will not be obtainable. Hence for the mainland States there will be a big gap in the information necessary for the compilation of such vital statistics as imports, exports and inter-state migration. But for Tasmania inter-state movements through land transport are

impossible and so the problem of "land transport" in the compilation of vital trading statistics does not arise. Thus, the geographical isolation of Tasmania has rendered it a more desirable study-region than any one of the other mainland States in Australia in so far as data availability is concerned.

Although trade statistics are available for Tasmania they are not made use of in the simple REM that we construct (in later chapters). These statistics would be indispensable for the construction of the more sophisticated REM, e.g. the Keynesian-type, as shown in chapter four. The construction of such sophisticated REM for Tasmania is not feasible at the present time because of the absence of other essential data.

The fact that Tasmania is the smallest State in Australia means that the Tasmanian economy must be heavily dependent on the Australian economy and consequently that the Tasmanian economy will be greatly influenced by fluctuations of the Australian economy. This is brought out very clearly in the regional empirical model for Tasmania constructed in Chapter Six in which three important Tasmanian aggregates are related to particular Australian aggregates so that the quantitative effect of variations in these Australian aggregates on the selected Tasmanian aggregates can be measured.

1.3 An Outline of the Study

The outline of this study is as follows. In this chapter the philosophical issues which underlie the development of regional econometric models for Tasmania are briefly discussed. Specifically, the distinct features of regional econometric models are discussed and compared with those of the national models. Also, we have discussed the regional unit in the present study.

Chapters Two and Three give a survey of a sample of twelve existing regional econometric models which we have selected from the literature. In Chapter Two, regional econometric models are classified into five broad types (named respectively, regional empirical model, regional economic base model, regional social accounting model, regional production function model, and regional input-output model) and the uses of such models into three types (forecasting, policy analysis, and planning). Then the appropriate uses for each type of regional econometric model are examined. In Chapter Three, a more detailed model-by-model description of each existing regional econometric model is given so as to bring out the fine points of regional econometric models.

In Chapter Four, a feasibility study of the Tasmanian economy is undertaken the main purpose of which is to decide on the types of regional econometric models which can be constructed for Tasmania. In this feasibility study, the following procedure is carried out. Firstly, a prototype model for each of the five classified types of regional econometric models discussed in Chapter Two is selected and, secondly, the data requirements for the construction of this prototype model are compared with the available Tasmanian statistics so as to decide whether this type of regional econometric model is feasible and worth considering further in the Tasmanian context. From the feasibility study undertaken it is concluded that, at present, only the regional empirical model and the regional economic base model are feasible.

Before the construction of these two types of regional econometric models is discussed, a digression is made in Chapter Five to the discussion on the estimation of gross state product for Tasmania. The importance and the concept of gross state product are discussed first,

and then the income-approach to the estimation of gross state product for Tasmania is outlined. Estimates of total gross state product, its principal components, and constant-price gross state product are presented.

Having made the digression, the study returns to the construction of a regional empirical model in Chapter Six for Tasmania and in Chapter Seven to the construction of two regional economic base models.

In Chapter Eight, the forecasting performance of the regional empirical model for Tasmania is compared with that of two intrinsic (naive) models.

In Chapter Nine a summary of the major results of this study is presented. Data tables are presented in the Appendix.

1.4 Abbreviations and Notations Used

To promote uniformity of presentation and to facilitate discussion, references will be cited by attaching a number of square brackets to the author's name. This number is the number of the reference in the Bibliography.

It should also be noted that the following abbreviations have been employed throughout:

<u>Abbreviation</u>	<u>Description</u>
REM	Regional Econometric Model
REMM	Regional Empirical Model
REBM	Regional Economic Base Model
EBM	Economic Base Model
RSAM	Regional Social Accounting Model
RIOM	Regional Input-Output Model
NEM	National Econometric Model
ANA	Australian National Accounts
CBCS	Commonwealth Bureau of Census and Statistics
ARMA	Autoregressive Moving Average Process
ARIMA	Integrated Autoregressive Moving Average Process

These abbreviations will be used both for the singular and for the plural depending on the context.

CHAPTER TWOUSES AND TYPES OF REGIONAL ECONOMETRIC MODELS2.1 Introduction

In this chapter we will give a general account of the common uses and types of REM. We have classified the many uses of REM into three categories. These have been named forecasting, policy analysis, and economic planning respectively. Also, we have classified the many types of REM into two broad types: empirical and the theory-based. The latter type has been further sub-divided into Regional Economic Base Models REBM, Regional Social Accounting Models RSAM, Regional Production Function Models RPFM, and Regional Input-Output Models RIOM respectively. Each of these uses and types of REM will be discussed in turn. Having done that, we will try to identify which particular type of REM is most suitable for a particular use.

2.2 Uses of Regional Econometric Models

In the past the main users of regional econometric models have been regional policymakers. Except for the few that have been developed as a matter of academic interest, most operating REM have been designed and used to help regional policymakers in policy formulation and in planning. For this reason, the uses of REM will be discussed from the standpoint of the regional policymaker. In the following discussion, the many uses of REM have been grouped under three headings. These are respectively (a) forecasting; (b) policy analysis; and (c) planning. We will discuss each of these uses of REM in turn.

The first use of REM to regional policymakers is in regional economic forecasting. In this application, REM are used to project certain important regional economic variables into the future. Such projections may assist regional policymakers in a variety of ways. For example, where regional policymakers are formulating regional stabilization policies they will need to know the likely future magnitudes of certain regional economic variables such as regional income, regional gross product, regional employment, and so on, before they can devise measures to stabilize the values of these variables. REM may also assist regional policymakers who are interested in promoting faster regional economic growth. For in such instances, the policymaker will require information about trends and future growth rates of certain regional economic variables which are relevant in the growth context.¹ A further example of the usefulness of REM forecasts to regional policymakers is where state authorities are required to balance their budgets. In this case, reliable forecasts of future state tax revenues are useful to state authorities so as to enable them to plan their state expenditures ahead. Some REM have been designed for this purpose.² In all the cases mentioned, reliable forecasts are obviously required so as to enable regional policymakers to decide on the right course of action.

A second use of REM to regional policymakers is in regional policy analysis. That is, in addition to providing information about

-
1. For an example of this application, see F. W. Bell [72]; R. J. Green [23].
 2. For instance, see M. Norman and R. Russell [44]; Research Seminar in Quantitative Economics [50].

the likely course of future events REM can be used to indicate how future events can be influenced by deliberate policy changes. To perform this latter function, specific policy variables must be incorporated into the REM, which will then contain three groups of variables: endogenous variables, predetermined policy variables, and other predetermined variables. The endogenous variables are those the behaviour of which is explained by the REM. These variables are concerned with the structural relationships which link together the separate parts of the economy under study. The predetermined variables, including the policy variables, are those which influence the endogenous variables without being affected by them. Typical examples of regional policy variables are the various state tax rates, state expenditures, subsidies, and so on. The three groups of variables are interrelated in the policy-REM in the form of a simultaneous equation system. For policy analysis, the equation system is solved by turning it into its "reduced form" in which each equation expresses an endogenous variable in terms of the policy variables and other predetermined variables only. Thus, the simultaneity of the original equation system is broken down in the reduced form. From this reduced form of the original system, the values of the endogenous variables can be calculated once the values for the relevant predetermined variables (including the policy variables) are given. In this manner, the effects of changes in any one of the policy variables on the endogenous variables can be evaluated so enabling the effects of changes in different policies to be compared. On the basis of such a comparison, regional policymakers can then assess the relative attractiveness of different policies before they make the final policy decision.

A third way in which REM can assist regional policymakers is in connection with regional planning which has now become an important activity in the regional field. The word "planning" connotes "... exploring interactions and attempting to order all actions, so that they may help and reinforce, rather than hinder one another."³ In other words, it suggests an attempt to coordinate actions. The tasks of regional planning are manifold, but the most important task of all is concerned with the coordination of the means of regional economic policy so as to attain specific regional goals. Thus, "planning" implies decisionmaking, a wish to influence events in a specified direction. Consequently, a planning model must "... allow for specific goals and policy objectives, and the planners via a manipulation of the instrumental variables under their control try to achieve these goals."⁴ Here lies, perhaps, the distinction between a planning model and a policy-REM as discussed earlier on. Whereas a policy-REM must provide the framework for policy formulation, a planning model must provide a framework for decisionmaking. For example, a policy-REM would provide forecasts of certain economic variables under alternative types of regional fiscal policy, but this econometric determination of the effects of the fiscal policy casts little light on the optimal regional fiscal policy for achieving desired goals. It is still necessary for the policymaker to have some consistent and rational criteria for determining optimal fiscal policy.

3. S. Czamanski [12], p. 10.

4. See H. W. Richardson [51].

The first operation in using an REM for planning is to insert into the model the goal or target variables. The goals may refer to a set of predetermined target levels, and the regional policymaker's job is then to adjust values for the instrumental variables in a manner which throws up a set of outcomes which is consistent with this set of target levels. This is often referred to as the "fixed" target approach to planning originally expounded by J. Tinbergen. A type of REM has been designed for this particular purpose.⁵

On the other hand, the goals in regional planning may refer to the maximization of some given index of welfare such as real income per head. This is the "flexible" target approach to planning as expounded by H. Theil. For this purpose, the planning model must include an optimising technique such as linear programming. Regional planning models, therefore, are often of the linear programming type.⁶

For regional planning, policymakers are often interested not only in the impact of regional economic policy upon aggregate economic variables, but in the relative impact upon different industries, regions, and income groups within the regional economy. For such a sectoral or structural analysis, an input-output model is often preferred. So regional planning models are frequently input-output models.

Note that given our definition of "planning", planning models are in a sense the inverse of policy models. For a policy model, the

5. See, for example, R. Artle [70].

6. For instance, see R.G. Spiegelman, E.L. Baum, and L.E. Talbert [55]; F.L. Golladay and A.D. Sandoval [89].

data and the instrument variables are the inputs, the endogenous or targets are the outputs. In the case of a planning model, on the other hand, the data and target variables become inputs into the model while the instrument variables are the outputs. The difference between policy and planning models can be illustrated by examining the type of problems to which they address themselves or the questions which they try to answer.

A policy model may answer, for example, the following question: What will be the rate of growth of gross regional product (GRP) given that the government intends to invest in the development of the regional economy one billion dollars over the next five years?

A planning model, on the other hand, will attack the problem in the following way: How much has the government to invest in the development of the regional economy over the next ten years in order to achieve a five per cent yearly growth rate of GRP?

2.3 Types of Regional Econometric Models

Regional econometric model-building, which started about two decades ago, has now advanced to the stage where certain distinct types of REM can be identified. These differ in such respects as the degree of aggregation, stringency of data requirements, and degree of complexity of model structure. Because of these differences, one type may be well suited for one particular purpose, such as forecasting, but not for some other purposes, such as planning. For the same reason, one type may be more expensive to construct and implement than the others. In the following discussion, we will concentrate on two broad types of REM. They have been labelled "empirical REM" and "theory-based

REM" respectively. The theory-based REM have been further subdivided into the following four types: Regional Economic Base Models REBM, Regional Production Function Models RPFM, Regional Social Accounting Models RSAM, and Regional Input-Output Models RIOM. We will discuss each type in turn, first beginning with the empirical REM (which from now on will be called Regional Empirical Model, abbreviated as REMM).

2.3.1 Regional Empirical Models

A REMM consists of a series of regression equations in which regional variables are related to national variables. Individual equations are unrelated to each other. Thus, equations of a REMM describe a one-way causal relationship between the national variables and the regional variables, the direction of causation running from the former to the latter.⁷ REMM are mainly used in forecasting. In this application, the values of the regression coefficients are assumed constant and unchanged between the sample period and the forecast period. Hence, given the projected values of the national variables, the regression equations which make up the REMM can be used to calculate the projected values of the regional variables. In order to obtain data on the relevant national variables, a highly recommended procedure is to link up the REMM with a related national econometric model.⁸ This procedure helps the regional model-builder not only in the estimation stage where he can obtain data on the required national variables directly from the data base of the related national model, it helps him also in

7. See Research Seminar in Quantitative Economics [50].

8. See L.R. Klein [108]. Also see G.R. Green [92].

the forecasting stage where he can obtain the projected values of the national variables from the solution of the same national model.

A REMM represents a simple approach to regional forecasting. It involves experimentation on a computer with a set of national variables to obtain the required regression equation between some of the national variables in the set and a particular regional variable. Thus, no knowledge about the structural relationships of the regional economy is required in this method of forecasting. This is an advantage in those cases when regional forecasting has to be made on the basis of a very limited knowledge about the regional economy. Also, in its emphasis on the use of national variables instead of regional variables, this forecasting approach has in fact minimized the use of regional data which are in most instances hard to come by. However, it also suffers from many weaknesses which have severely limited its use. One big weakness of the REMM is that they are purely "empirical" in the sense that the forecasting equations used have not been formally derived from existing economic theory. Because of this lack of a good theoretical foundation, REMM suffer from the same weakness as other statistical forecasting devices such as the pragmatic (mechanical) trend extrapolation methods or the "naive methods", in that they do not provide an analytical framework within which any failure in the forecast can be diagnosed. The other weakness of the REMM is that, because of their total dependence on national variables, they tell us virtually nothing about the working of the regional economy itself. For instance, REMM do not deal with the consumption behaviour of the region's residents nor with the investment behaviour in the region.

2.3.2 Theory-based Regional Econometric Models

In the previous section, we have discussed the REMM. We have identified two main weaknesses of REMM. These are, firstly, that REMM do not have a good theoretical foundation, and secondly, that this type of REM tells us virtually nothing about the regional economy with which they are concerned. Now, we will turn our discussion to the other type of REM - theory - based REM. The theory-based REM that we will discuss are invariably built on some sort of theoretical foundation, and are concerned with the structural relationships of the regional economy under study. Hence, they are free of the weaknesses which haunt the REMM. In the following discussion, we will concentrate on four types of theory-based REM. They have been labelled as Regional Economic Base Models REBM, Regional Social Accounting Models RSAM, Regional Production Function Models RPFM, and Regional Input-Output Models RIOM respectively. These four types of theory-based REM vary in the degree of aggregation. The REBM is the most aggregative. At the other extreme, the RIOM is the least aggregative. The degree of complexity of model construction also varies with each type of theory-based REM. The REBM are the simplest and usually consist of only two equations, whereas the RSAM and RIOM are much more complicated and include many equations. We will discuss each type in turn, first beginning with the Regional Economic Base Models.

2.3.2a Regional Economic Base Models

The main use of REBM is to obtain estimates of regional multipliers from which the impact on total regional income and employment of increases or decreases in a region's export activities can be measured.⁹ REBM view the total economic activity in a region as composed of export activities and non-export (service) activities; and assume that, for a small region, export activities determine a large part of total regional activity. The REBM further asserts that a stable relationship exists between export activities and total regional activities such that an expansion in export activities leads to an increase in local income (income of the residents in the region) which in turn induces an increase in retail sales and various service trades, which lead in turn to a further expansion of local income. Hence, through this multiplier process, total regional income and employment will grow by some multiples of the initial increases in export activities. Regional multipliers then represent an attempt to quantify this hypothesized relationship.

The simplest way to obtain estimates of regional multipliers is to take the ratio of total employment to export employment for a given year, i.e.

$$(2.1) \quad k = T/X,$$

where

T = total regional employment,

X = export employment, and

k = the regional employment multiplier estimate.¹⁰

9. See R.W. Pfouts (ed.) [48] for a good collection of discussions on REBM.

10. In this exposition, we have employed employment rather than income as the basic unit of measurement.

Alternatively,

$$k = T/X = (S + X)/X,$$

$$(2.2) \quad k = 1 + \left(\frac{S}{X} \right),$$

where

S = level of employment in the "service" or "local" industries.

Thus, the regional employment multiplier estimate k is given by one plus the so-called base-service ratio $\left(\frac{S}{X} \right)$. So, when the simple REBM is used for projection purposes, the method is to identify the base, calculate the base-service ratio, and apply it to expected movements in the base in order to project the change in total activity. In such a projection, the base-service ratio is assumed constant between the period from which the estimate is made and the forecast period.

The above simple way of obtaining the regional employment multiplier k is unsatisfactory because the value of k is determined by the magnitudes of one particular year only. A more satisfactory estimate of k would be some average figure taken over a number of years. If data are available for a number of years, it is possible to derive an estimate of k from the REBM as expressed by the following two equations:

$$(2.3) \quad T = S + X$$

$$(2.4) \quad S = a + bT,$$

where the symbols T, X, and S have already been explained above, and a and b are parameters.¹¹

Equation (2.3) is an identity which expresses total employment as the sum of service and export employments. Equation (2.4) expresses the relationship between service employment and total employment. Solving equations (2.3) and (2.4) gives

$$(2.5) \quad T = \frac{a}{1-b} + \left(\frac{1}{1-b} \right) X$$

This gives $k = \frac{\Delta T}{\Delta X} = \frac{1}{1-b}$. So, by regressing S on T as in equation (2.4) above, we can get an estimate of the parameter b, and from this value of b, we can calculate the regional employment multiplier k.

While simple in construction and theory, REBM are loaded with both conceptual and technical problems when used for projection purposes.¹² One big conceptual problem of the REBM when used in forecasting is the assumption of a constant base-service ratio. In view of the many forces that can affect this ratio, the constancy assumption is not acceptable to many critics. It has been suggested

11. Note the resemblance of the above formulation of the REBM to the Keynesian model of national income determination.

12. These problems have been widely discussed. See for example W. Isard [30].

that in the long run particularly, the base-service ratio is very likely to alter due to changes in the structure of the regional economy. These structural changes include such things as variations in the degree of specialization due to changes in the locational factors which affect the region, development of import substitutes, and so on.¹³ The other problem in the use of REBM for forecasting purposes concerns the projection of the basic industries. Recall that to project total regional income or employment with the REBM we need first to project employment in the basic industries. Such projections are usually done by independent forecasting methods. Since REBM provide no guideline as to how these export activities are to be projected, this critical step in the projection procedure lies outside the framework of base analysis.

The main technical problem associated with REBM is that of identifying the basic industries or sectors. Which activities are basic? Which are service? How does one treat a firm which sells its output to another local firm when the latter exports its output? Researchers with REBM handle this classification problem in a number of ways. The first way is to make certain assumptions concerning the relevant market for the products of a given industry. In studies which adopt this approach, manufacturing has been in most cases assumed basic, while the traditional service sectors have been assumed non-basic. The second way is to use the "location quotient" or "concentration ratio". This measure seeks information about the relative specialization of a given region. If the region is found to have more than its

13. See H. W. Richardson, *Ibid.*, pp. 336-339.

proportional share of national production of a given good, the amount greater than proportionality is assumed to be exported. This method though useful, suffers from several deficiencies such as the implicit assumption of uniform national consumption and production patterns. Another way to solve the problem of identifying the basic sector is to conduct firm-by-firm interviews. This is of course an expensive method.

Because of these conceptual and technical problems, REBM are not well-suited for forecasting purposes. For such purposes, the next two types of theory-based REM, i.e. Regional Social Accounting Models RSAM and Regional Production Function Models RPFM, which we are to discuss are more suitable. We will discuss the RSAM first and then in Section 2.3.2c we will discuss the RPFM.

2.3.2b Regional Social Accounting Models

Like the Regional Economic Base Models, RSAM are aggregative tools of analysis which deal with such economic aggregates as total regional income, employment, and output. However, their level of aggregation is not as great as REBM. Whereas REBM adopt a two-sector (exports-service) division, RSAM usually divide the regional economy into more than two sectors, such as the household sector, the business sector, the government sector, the foreign sector, and so on. Some sectors will be considered as exogenous and other as endogenous. RSAM give estimates of aggregate multipliers which can be used to measure the multiplier effects of any autonomous change in an exogenous sector on the endogenous sectors of the regional economy. RSAM are also used to forecast such variables as income, employment, output, prices and

wages. Finally, they are also well suited for policy analysis purposes.

Unlike the two-equation approach of simple REBM, RSAM usually consist of a large number of interdependent behavioural equations. These equations are estimated by regression techniques employing time series data and, in this manner, economic theory is tested empirically. RSAM are more flexible than REBM in the sense that whereas the construction of REBM is dictated by a specific theory, RSAM are not bounded by any particular theory.

RSAM are designed to forecast the immediate future and hence the name short-run forecasting model is usually applied. They usually employ a forecasting period of less than five years and are concerned with forecasting cyclical fluctuations in the regional economy in the immediate future. They are national-income determination models of the Keynesian type and thus emphasize aggregate demand and its various components. Implicit in this type of model is the Keynesian view of income determination, i.e. that aggregate demand plays the dominant role in determining the level of economic activity. Behind such a Keynesian framework is also a set of income and product accounts which gives rise to the Identity between gross regional product and the various expenditure components of consumption, investment, government, and net foreign trade purchases. From this Identity, the short-run RSAM develop in various directions. The various demand components are usually disaggregated and explained in this type of model. So there will be a regional consumption function, investment functions, and so

on. Government expenditures are also explained within some of the short-run RSAM.¹⁴ Because of the important fact that regional economies are "open" in terms of commodity flows, exports and imports are also explained in the model. Besides the expenditure equations, regional income and its components are also explained in the RSAM. These income components are joined to the "real" sector through the various prices. To facilitate policy analysis, institutional equations like direct and indirect taxes functions, national taxes, transfer payments equations, and so on, are also added. To throw some light on the regional unemployment problem, the aggregate demand for commodities is transformed through a labour demand function to derive the demand for labour, and by comparing this with the labour supply, the level of regional unemployment can be determined. All in all, the short-run RSAM focus on aggregate demand and its various components. Although factor-supply equations, e.g. wage and price equations, may also be present, they are relatively of less importance.

The other type of aggregate theory-based REM which we are to discuss is the Regional Production Function Models RPFM. Unlike RSAM which are concerned with short-run analysis, RPFM are concerned with the analysis of structural change and regional economic growth. Hence, they are called long-run forecasting models, and to the discussion of this type of REM we will now turn.

14. See, for example, L. R. Klein [108]; E. M. Gramlich [91].

2.3.2c Regional Production Function Models

RPFM are long-run aggregate growth models which are used to project regional economic growth. By contrast with the short-run RSAM discussed above, the long-run RPFM pay more attention to the supply side of the region and less attention to aggregate demand and its components. A production function is most essential in RPFM. Other supply-side equations, e.g. the wage rate equation, the investment function, and equations representing the supply of both capital and labour services, are also necessary in RPFM. In these respects, therefore, RPFM are analogous to those aggregate national econometric growth models which have relied on an analysis of the production function to deduce the determinants of the rate of growth.¹⁵ But, unlike these national growth models which emphasized capital formation and technical progress as the main determinants of growth, RPFM have relied on a different mechanism to explain regional growth.

One type of RPFM emphasizes the role of exports as the main determinant of regional growth. In this type of model, an Economic Base Model has been incorporated into the main body to explain regional economic growth. Recall that in the previous discussion of REBM, we mentioned the exports-service dichotomy of the economic base framework. In long-run models of the type now under discussion, export industries are defined as those which serve national markets while service industries are taken to be those which serve only the regional economy. Given such a classification, regional exports are connected to some national variables, e.g. GNP, which represents the national potential

15. See, for example, P. E. Smith [131]; R. M. Solow [132].

to import from the region while service output is related to regional income. From such a formulation, fluctuations and growth in the national economy will affect the region's export activity which, in turn, affects local production. Through such a formulation, the national demand for regional product is transformed into local demand for local production. Then, through the regional production function (or more exactly the regional labour demand function), the aggregate demand for local production is translated into the demand for labour. From then on, equations for regional unemployment, wages, and so on, can be derived.

Another type of long-run RPFM makes use of "location theory" to explain regional economic growth.¹⁶ According to location theory, regions grow because of increases in fixed capital investment. An open region is viewed primarily as a place competing with all other places in the nation in efforts to attract new investment, especially new productive investment. This new investment takes place on the basis of the individual location decisions of entrepreneurs who often may not be residents of the region. So this type of RPFM focuses on the locational factors which might affect investment decisions.

2.3.2d Regional Input-Output Models

REBM, RSAM, and RPFM are aggregative approaches to the study of the regional economy. They are used to deal with such aggregates as total regional income, employment, output, and so on. From these types of REM, we can derive aggregate multipliers so as to assess the

16. See S. Czamanski [12].

multiplier effects of any exogenous "shock" on the aggregates of the regional economy. Although aggregate multipliers are useful devices, they suffer from the limitation that they do not show the details of how multiplier effects work themselves out. Assume, for example, that a decision has been made to stimulate economic activity by means of investment in public works. There will be an immediate impact on the construction industry, but how will the effects of stepped-up construction activity ramify throughout the economy? To answer a question such as this, we will have to use a RIOM which describes, in a fair amount of detail, the interrelationships between industries or sectors and so shows in detail the inter-industry effects of exogenous shocks to a region. As well as being used extensively in regional impact studies,¹⁷ RIOM have been used both for forecasting and for planning.¹⁸

According to the theory underlying RIOM, each producing sector in the economy is said to be dependent upon every other sector. In that manner, output from sector 1 may be used as an input to sector 2; sector 2's output, in turn, may be input to production for sector 3, and so on. This analytic system allows for the tracing of multiplier effects emanating from exogenous shocks to the economy in a more detailed manner than do REBM or RSAM. In an open, static economy, the following accounting balance holds in each of the economy's m industries:

17. See W. Isard and W. Kuenne [104].

18. See Chapter Three.

$$(2.6) \quad X_i = \sum_{k=1}^m x_{ik} + Y_i \quad i, k = 1, 2, \dots, m$$

where

X_i = total output in industry i ,

x_{ik} = amount of industry i 's output absorbed in the production of industry k 's output, and

Y_i = amount of industry i 's output absorbed by final demand.

In equation (2.6), the output of industry i is divided between inter-industry ($\sum_{k=1}^m x_{ik}$) and final (Y_i) uses. The latter consists of demand for consumption, investment, government purchases and foreign trade purposes.

Since the data requirements for this type of study are stringent, simplifying assumptions have to be made. The following are typical:

- (a) Each commodity group is produced by a unique producing industry.
- (b) No external economies or diseconomies are possible.
- (c) There is a unique observable production process which does not allow for the substitution of inputs,¹⁹ i.e. constant production coefficients.

Assumption (c) implies

$$(2.7) \quad x_{ik} = a_{ik} X_k$$

where

a_{ik} = production coefficient specifying the amount of i needed to produce one unit of k , and

X_k = output in industry k .

19. These points have been discussed in W. Isard, *Ibid.*, pp. 319-362. and W. H. Miernyk [39].

Substituting (2.7) into (2.6) yields

$$(2.8) \quad X_i = \sum_{k=1}^m a_{ik} X_k + Y_i \quad i = 1, 2, \dots, m$$

Equation (2.8) is a system of m linear equations and may be solved for X_i if the distribution and level of final demand (Y_1, Y_2, \dots, Y_m) is known.

In matrix notation, equation (2.8) may be written as

$$X = AX + Y$$

and solved for the vector X by matrix inversion,

$$X = (I - A)^{-1}Y.$$

As pointed out above RIOM assume constant production coefficients. This assumption implies that a doubling of inputs will lead to a doubling of output, i.e. economies of scale are effectively ruled out. The constant-coefficients assumption has been widely criticised as being unrealistic, especially for the analysis of regional economies in which economies of scale, due to localization and urbanization, undoubtedly exist. The former arises from the location of many plants in the *same* industry in close proximity to each other so that specialized services are provided at lower cost. Urbanization economies are external economies which occur when firms in *different* industries locate at one locality and a corresponding urban infrastructure is built to service them. In cases where either type of external economy exists, the assumption of constant-coefficients is likely to be misleading.²⁰

20. In the long-run, economies of scale will most likely exist. Hence, RIOM are not suitable for long-run forecasting purposes. See W. Isard, *Ibid.*, p. 327.

The other main problem of RIOM is concerned with the difficulty of obtaining data, henceforth referred to as "the data problem". Many of the weaknesses of RIOM derive ultimately from the data problem. For instance, to implement the Input-Output approach, it is necessary to have data on both the industrial origin and destination of sales and purchases for each firm in the region. Since data of this nature is usually not collected, regional input-output model builders have either to undertake the expensive and time-consuming task of primary data-gathering, or make use of national coefficients taken from national studies.²¹ The latter method of course involves the dubious assumption that regional production and trade patterns are the same as national ones. This imposes a serious limitation on the usefulness of these studies. Obviously there is an advantage in the direct method of estimating regional tables; however, the advantage of more accurate coefficients must be weighed against the disadvantages of the higher cost of research.

2.4 Which Type for which Use?

In the first section of this chapter, we discussed the three general uses of REM. They are respectively forecasting, policy analysis, and planning. Then in the second section, we discussed the different types of REM that have been developed and used. We have identified two broad types of REM. They are the empirical- and the theory-based REM. Among the theory-based REM, we have further isolated

21. Most early regional input-output studies employed national coefficients. See W. Isard and R. Kuenne, *Ibid.*

four distinct types of REM and they have been labelled as Regional Economic Base Models REBM, Regional Social Accounting Models RSAM, Regional Production Function Models RPFM, and Regional Input-Output Models RIOM. In the process, we have also mentioned some advantages and disadvantages associated with each type of REM. Now in this section, we will try to compare the relative advantages and disadvantages of each type of REM for each of the three uses mentioned in Section 2.2. In so doing, we hope to cast some light on their potential usefulness and limitations in regional research work.

Right at the outset, we have doubt on the approach taken by the REMM. As explained, REMM are not analytical tools because they have no theoretical foundation. However, they do provide an expeditious method of regional forecasting because they use little regional data and hence are not expensive to construct. Turning to the theory-based REM, we will first begin with the *forecasting* use. Neither REBM nor RIOM are satisfactory for forecasting purposes. Basically, REBM are not forecasting devices. They are used only to bring out, in a rather inexpensive way, the structural relationships between export activities and local activities. When used for forecasting an REBM involves the dubious assumption of a constant base-service ratio. Moreover, this method fails to provide any guideline as to how the critical step of projecting employment in the basic industries is to be made. RIOM are also not suitable for forecasting purposes. Basically, a RIOM is a static device which describes the structural interrelationships between the various sectors at some particular point in time. Although some attempts have been made to adopt input-output analysis for long-run dynamic analysis, the procedures involved are

rather cumbersome, and the method needs to be refined further before it can be made operational.²² In addition to this, the assumption of constant production coefficients also limits the usefulness of RIOM as a forecasting tool. This leaves only the RSAM and the RPFM to be considered. For forecasting purposes at least, RSAM and RPFM are superior to both REM and RIOM. They are not dictated by any particular theory about the regional economy and hence offer a more flexible approach to regional analysis. Also, RPFM can be adapted easily for long-run analysis as most RPFM are dynamic rather than static.

Next we consider the relative merits of these four types of REM when used in *policy analysis*. For this particular application, we can easily discard EBM because they are not built for policy analysis. Similarly, RPFM which are designed for the sole purpose of projecting long-run regional growth are not well suited for policy analysis, and, therefore, can also be discarded. As for RSAM and RIOM, the former are superior for some types of policy analysis and the latter for others. RSAM give the effects of policy changes on aggregate variables and are therefore useful for dealing with such broad policy issues as regional stabilization and the promotion of faster regional growth. On the other hand, RIOM are much more disaggregative, and can be used to trace the industry-by-industry effects of any policy changes. In some cases, this kind of detailed analysis is more useful to regional policymakers than the corresponding aggregative analysis of RSAM.

22. See W. H. Miernyk, [39] for a discussion on this point.

Lastly, when it comes to regional *planning*, RIOM is to be preferred to all the other types of REM. As mentioned earlier, the main task of planning is to coordinate the means of economic policy so as to achieve the aims. At the regional level (even when the region is as big as a state), aggregative models such as RSAM are not useful for planning purposes since there are no tools of aggregative economic policy available to regional level governments or to the federal government operating at the regional level. It has been said that aggregative policy instruments, such as the monetary and fiscal policies, are irrelevant to the dealing of problems in specific regions.²³ But rather, the argument continues, the nature of the available regional policy instruments is such that they are operative only at a much more disaggregative level (e.g. at the industry level) and are essentially of the following two types:

- (a) Investments in social and physical infrastructure, and
- (b) Inducements for industry location.

The planning questions at this level are, therefore, connected with the allocation and the optimal use of these instruments. To answer these planning questions, the use of a highly detailed model, like the RIOM, is required.

The above discussion on the relative merits of each type of REM has been conducted only from the point of view of how they satisfy a particular purpose. To make the final choice, one has to take into consideration other factors such as the limited resources available to the researcher, data availability, and the particular problems facing

23. See R. G. Spiegelman, "Models for Regional Development Planning" in V. P. Rock (ed.) [52].

the regional economy under study. RSAM and RPFM seem to be a good compromise between REBM and RIOM. REBM require little data and are therefore relatively less expensive to construct. But, of course, the amount of information that they can convey to the model-builder is limited. On the other hand, RIOM are complicated and are expensive to construct. They are, however, more comprehensive in coverage. Both RSAM and RPFM require more data than REBM and less than RIOM, but at the same time they also provide more information than REBM and much less than RIOM. Hence, they make a good compromise between the REBM and the RIOM.

Finally, it must be emphasized that the various types of REM mentioned are complementary rather than competitive. Suppose that an RIOM is to be used to analyse inter-industry or intermediate demand. This will require a projection of the final demand sector and this projection can best be done by means of a RSAM. Thus, the outputs from a RSAM can serve as inputs to an RIOM making the former type of REM a good complement to the latter. In like manner, outputs from an REBM can be employed as inputs to a RIOM or to a RPFM.

CHAPTER THREEA GENERAL ACCOUNT OF EXISTING REGIONAL ECONOMETRIC MODELS3.1 Introduction

In Chapter Two above, we have looked into the common uses and types of regional econometric models and in the process we have presented a catalogue of important differences and a comparative analysis of alternative approaches in the development of REM. Now in this chapter, we want to have a closer look at some examples of each of the various types of REM that we have distinguished in Chapter Two.

During the past ten years a number of large-scale REM have been developed in the United States. This chapter will discuss the general features of twelve of these regional models to illustrate the general state of the art. This survey is not comprehensive either in terms of coverage or depth. The purpose is to set the stage for an examination of the feasibility of constructing models of the various types distinguished in Chapter Two for the Tasmanian economy and to assist in the construction of such as prove to be feasible. The twelve REM to be discussed are (1) The Michigan model (1) developed by the research team in the University of Michigan [50]; (2) The Michigan model (2) by D. A. Leabo [112]; (3) The Los Angeles model by G. H. Hildebrand and A. Mace, Jr. [100]; (4) The Hawaii model by K. Sasaki [130]; (5) The Puerto Rico model by M. Dutta and V. Su [82]; (6) The Ohio model by L'Esperance, *et. al.*, [113]; (7) The Illinois model by R. J. Green [23]; (8) The Massachusetts model by F. W. Bell [72]; (9) The Philadelphia model by N. J. Glickman [88]; (10) The

Nova Scotia model by S. Czamanski [12]; (11) The Oahu, Hawaii model by R. Artle [70]; and (12) The New Mexico model by F. L. Golladay and A. D. Sandoval [89]. These two models will be discussed under similar headings which we adopted earlier in Chapter Two. Accordingly, the first two models will be discussed in Section 3.2 under the general heading "Existing Regional Empirical Models", while the remaining ten will be discussed in Section 3.3 under the general heading "Existing Theory-Based Regional Econometric Models". Furthermore, these latter ten models have been classified separately into the four types of theory-based REM which we described in Chapter Two, i.e. the Regional Economic Base Models, the Regional Social Accounting Models, the Regional Production Function Models, and the Regional Input-Output Models. In particular, models (3) and (4) will be discussed under the heading of REBM; models (5) through (7) under the heading of RSAM; models (8) through (10) under the heading of RPFM; and the last two models under the heading of RIOM.

These twelve models are generally representative of current thinking. They offer a coverage that is sufficiently broad in scope in terms of the type of region analysed and the particular techniques used to provide a good general background. In the discussed to follow, we will give a model-by-model description of each of these twelve models. In this connection, we will concentrate on describing the broad structure of each model rather than attempting to give an equation-by-equation account, although the latter will appear appropriate at times (e.g. in Sections 3.3.3a and 3.3.4a). Also, since in this chapter we are interested mainly in the broad structure of the models the fine points of the econometrics such as the estimation methods

employed, and problems associated with the data will not be covered.

For clarity of exposition, many simplifications are introduced.

The notation used is not necessarily that of the model being discussed, nor is the numbering of the equations.

3.2 Existing Regional Empirical Models

As described previously in Chapter Two, a REMM is one in which all the independent variables are national variables, e.g. GNP and the various expenditure components of GNP, while the dependent variable is a particular regional variable. We will present two examples of REMM. Both models have been developed for the state of Michigan in the United States, and accordingly, they are named the Michigan model (1) and the Michigan model (2) respectively. We will first discuss model (1).

(a) The Michigan Model (1)¹

This model is used to project annual changes in certain economic aggregates for the state of Michigan in the United States through a series of independent (i.e. one-way causal) regression equations estimated from first-difference data. The dependent variables include gross state product and its various industrial components, several types of employment, a variety of retail sales, total personal income and its components, population, and various state taxes. One purpose of the projections is to give reliable forecasts of future state revenues which are useful to the state authorities in planning

1. Research Seminar in Quantitative Economics [50].

their expenditures ahead while attempting to balance their budgets.² The independent variables are mostly national variables relating to the U.S. economy. The total number of forecasting equations in the model is seventy-eight.

As described in the original study, the Michigan economy is dominated by its manufacturing sector.³ Automobiles and steel productions in particular have been the most important activities in the Michigan economy, and so fluctuations in the U.S. demand for automobiles and various capital goods will induce big fluctuations in the activities of the Michigan economy. This fact is also used to justify the exclusive use in the model of three particular national variables: the U.S. demand for automobiles AUTO; the U.S. demand for new producers' durables PD, and the other U.S. private final demand. A typical equation in the Michigan model (1) is the one which explains annual changes in gross state product, namely

$$(3.2.1) \quad \Delta GSP = -0.626 + 0.228\Delta AUTO + 0.136\Delta PD + 0.08\Delta OTHER$$

The regression coefficients can be considered as weights attached to the three national variables to represent their individual contributions to the explanation of annual changes in GSP. Considered in this way, equation (3.2.1) suggests that an increase in the annual change of one

2. See Chapter Two, Section 2.2 about this Use of REM.

3. This is substantiated by comparing the ratio $\left(\frac{\text{Manufacturing GP}}{\text{Total GP}} \right)$ for both Michigan and the U.S. In 1963, the Michigan ratio was 45%. cf. the U.S. ratio of only 28% which implied heavy concentration of manufacturing activities in Michigan.

of the national variables AUTO, PD, and OTHER, the other two being held constant, will induce an accompanying increase in the annual change of GSP equal to approximately twenty-three per cent, fourteen per cent, and eight per cent, respectively of the annual changes in the variable concerned. In like manner, the three industrial components of GSP: manufacturing; trade; and other services; are explained by these three national variables. The remaining industrial components of GSP are explained by somewhat different procedures, however. For instance, gross product originating in agriculture is explained by an annual trend; government product is assigned on the basis of budgetary and expenditure projections based on needs; mining product is regressed on the level of U.S. construction activity (net of residential construction); and gross product originating in construction is determined by a statistical formula.⁴

The three national variables (Δ AUTO, Δ PD, and Δ OTHER) are also used to explain retail sales and its various components. But in this case, not all the three national variables are used in the same equation as is done in the equation which explains Δ GSP. For instance, the equation which explains annual changes in total retail sales Δ RS has included both Δ AUTO and Δ OTHER but not Δ PD, the latter being left out because it contributes little to the explanation of Δ RS. Again, the equations for retail sales in general stores and in furniture stores include Δ AUTO and Δ PD but not Δ OTHER.

We turn next to the equations for total employment and the various types of employment. Total employment is disaggregated into

4. For details, see Research Seminar in Quantitative Economics, *Ibid.*

agricultural employment and various categories of non-agricultural employment. Agricultural employment is explained by an annual trend. As for the various categories of non-agricultural employment, manufacturing employment is explained by ΔAUTO and ΔPD , non-manufacturing employment by ΔPD alone, and self-employment by an annual trend. Government employment is assigned a value as in the case of government product.

The model also explains population, labour force, and unemployment. Annual changes in population ΔP is thought to be due to two sets of factors: natural increase and net migration. Natural increase is explained by an empirical relationship while net migration is explained by the difference between the unemployment rates of Michigan and the U.S., both current and lagged one year. Annual change in the labour force ΔL can be calculated by applying a constant labour participation rate to ΔP . The difference between ΔL and ΔE (annual change in total employment) gives the annual change in the level of unemployment ΔU .

Finally, we will describe the treatment of total personal income and its components in the Michigan model. Total personal income is disaggregated into wages and salaries by major sectors, other labour income, property income, transfer payments, and social insurance payments. Annual changes in total personal income is regressed on ΔAUTO and ΔPD . In addition to these two national variables, other national variables such as expenditure on gas and oil, transport services, and food and beverages, are also used to explain various types of wage and salary income and property income. For other components of personal income, procedures similar to that used in determining the various components of GSP and retail sales have been adopted.

Given the forecasting equations for gross state product, employment, retail sales, personal income, and the various components of the above variables, the model can be used to project state tax revenues. This is said to be the prime objective of the Michigan model (1).⁵ However, this projection procedure is not reported in the original study and is therefore not covered in this survey.

The structure of the model is entirely geared to national demand factors. Little consideration is given to the determination of any independent influence of local demand. That is, none of the (endogenous) state variables are influenced by other (endogenous) state variables, only by (exogenous) national variables. Retail sales, for instance, are usually generated by local spending, but, in the Michigan Model (1), are a function of U.S. Automobile Expenditures and Other Private Gross National Product. A more realistic model would relate them to local variables such as personal disposable income.

The presentation of the model was evidently intended for officials without statistical background, for it contained no measures of the "goodness-of-fit" of the regressions, other than occasional references to the amount of variation accounted for. Although little discussion of technique is included, ordinary least squares regressions seem to have been used.

5. See Research Seminar in Quantitative Economics, Ibid.

(b) The Michigan Model (2)⁶

Michigan model (2) is similar in structure to Michigan model (1) in that it attempts to relate a particular regional variable to a set of national variables. However, it is much more limited in its scope. Unlike the more comprehensive Michigan model (1) which attempts to develop seventy-eight forecasting equations for a set of regional variables as described earlier, model (2) attempts to develop only eight relationships. These are for total personal income and seven industrial components of wage-income, namely wages and salaries originating in manufacturing, finance, insurance and real estate, wholesale and retail trade, constructions, transport and public utilities, state and local government, and services. A total of ten potentially relevant national variables have been tried by a stepwise regression procedure⁷ in order to identify the statistically significant regressors. Six have been so identified. They are respectively GNP, total U.S. unemployment TOTUEM, industrial production ENLPRD, manufacturing and trade sales MFGTRS, retail sales RETSLS, and manufacturers' shipments, inventories and new orders MFGSIO. Thus, the set of significant independent national variables used in model (2) is different from that used in model (1).

6. D.A. Leabo [112] .

7. For a discussion on Stepwise Regression, see Section (6.2) in Chapter Six.

The Michigan model (2) is also different from model (1) in respect of its intended use. Whereas model (1) is designed primarily for forecasting, model (2) is designed to study the sensitivity of the state's income to fluctuations of the nation's economy. That is, model (2) is designed to measure the increases or decreases in personal income originating in various industries in Michigan as a result of a cyclical rise or decline in general business conditions in the nation's economy as represented by some percentage increase or decrease in some of the national economic indicators. This sensitivity of Michigan's personal income to economic conditions nationally was studied through the eight stepwise regressions using first difference data. Each industrial component, as well as total personal income, was correlated with the selected national economic indicators. From these eight regressions, the effects of a 5% rise and then a 5% fall in the national economic indicators on total Michigan personal income and its seven industrial components were measured. It was found that for a 5% rise in the national economic indicators, total personal income, wage and salary income in manufacturing, and wage and salary income in finance, insurance and real estate increased by 6.3%, 7.2%, and 8.0% respectively, whereas for a 5% fall in the national economic indicators, the corresponding figures were 1.3%, -3.7%, and 3.8%. From these results, it was concluded that "... while total Michigan personal income,

wages and salaries, and finance, insurance and real estate wages and salaries tend to rise faster than the nation's economy on the upswing they do not drop as far."⁸ In the same way, the sensitivity of other industrial components of personal income was also studied.

3.3 Existing Theory-Based Regional Econometric Models

In this section, we will present ten of the existing theory-based REM. By contrast with the empirical REM discussed in the previous section, these ten models are invariably developed through consideration of some economic theory rather than as the result of empirical experimentation. Also, they are designed to study the structural relationships in the regional economy rather than merely to serve as an expedient forecasting tool. The ten models in question have been classified into four main groups: REBM, RSAM, RPFM and RIOM. Each will be discussed in turn under the appropriate heading, beginning with the REBM.

3.3.1 Regional Economic Base Models

Recall that in Chapter Two, Section 2.3.2a above, it was pointed out that the main use of REBM, in general, is to obtain estimates of regional employment and income multipliers. It was pointed out also that in order to obtain estimates of regional multipliers, total industry employment or income must be divided up into the basic and the service (non-basic) portions (i.e. the base-

8. See Leabo, *Ibid.* p. 547.

identification problem). Now, we will present two examples of REM to illustrate how the base-identification problem has been solved in existing REM in order to obtain regional multiplier estimates.

(a) The Los Angeles Model⁹

This study was a pioneer work in empirical REBM. Through exploration of the employment multiplier hypothesis, the authors suggested that by "... correlating changes in localized community employment with changes in non-localized community employment, [it was possible] to derive an employment multiplier for the 'export' trades in a local area."¹⁰ No formal model was presented, however. Monthly employment data was used to obtain estimates of the employment multiplier for the period 1940-47. The region under study was the Los Angeles county in the United States.

In accordance with the employment multiplier hypothesis,¹¹ community industries were classified separately as localized (home production) or non-localized (export). This was done on the basis of the industry's location quotient which was defined as a measure of the relative concentration of employment in a given industry in one area compared with another area. Employment location quotients were calculated industry-by-industry for each of 44 industry groups. These were then used as indexes of the primary market orientations

9. G. H. Hildebrand and A. Mace, Jr. [100].

10. Note that the original authors used the terms "localized" and "non-localized" employment. This corresponds to our usage of "non-basic" and "basic" employment in Chapter Two, Section 2.3.2a.

11. See Section 2.3.2a, Chapter Two for a discussion of the regional multiplier hypothesis.

of industries in the region. Industries with "relatively high" location quotients were classified as "export" industries in the region. Since the authors were not satisfied with an arbitrary designation of, say, 1.00 as a minimum quotient value in the comparative classification procedure, they decided to obtain by statistical means¹² such a minimum limit. They then decided that 1.508 was the proper value of the statistical limit desired for the classification procedure.

Once the industries of Los Angeles county had been allocated to either the localized or non-localized category, they were summed to give total localized employment in the county x_1 and total non-localized employment in the county x_2 for each month. A regression of x_1 on x_2 was run using the available 37 pairs of monthly observations for selected years in the period 1940-47. The equation obtained was

$$(3.3.1) \quad x_1 = 222,000 + 1.248x_2,$$

with a correlation coefficient of above +.95. On the basis of such a high value of the correlation coefficient obtained, the authors were satisfied with the regression results and concluded that the correct employment multiplier estimate for Los Angeles county was 1.248 for the period 1940-47.

12. See Hildebrand and Mace, *Ibid.*, p. 246.

(b) The Hawaii Model¹³

In this study, the author uses a very simple model to evaluate the effect of defense expenditures on employment. The model is a typical economic base study, dividing the economy into "basic" and "non-basic" industries. The criterion for the dichotomy is whether the output of the industry is exported or sold locally, the basic assumption being that external trade is the primary propellant of the economy. The classification of industries is done through both the use of location quotients and some other simplifying procedures.

Total employment T is divided into two components: employment in locally-oriented industries L , and employment in export-oriented industries X :

$$(3.3.2) \quad T = L + X.$$

Next, it is assumed that employment in locally-oriented industries is a function of the level of total employment:

$$(3.3.3) \quad L = a + bT.$$

Actually, the author expresses L as a function of the current value of T and lagged values of T . However, as his appendix indicates, the introduction of lagged employment does not affect the estimates of the multiplier, and the model can be expressed in a simpler way by utilizing this fact.

13. K. Sasaki [130].

Substituting for L in equation (3.3.2), we can express total employment as a function of export-oriented employment:

$$T = \frac{1}{1 - b} (a + X)$$

where $(\frac{1}{1 - b})$ is the employment multiplier $(= \frac{\Delta T}{\Delta X})$.

To estimate the multiplier, data on total employment and on locally-oriented employment are needed. The data on total employment were available. To construct data on the locally-oriented employment, three methods were used:

- (a) When data on exports and outputs were available, total employment in the industry was divided into export- and locally-oriented by multiplying total employment by the ratio of exports to total output.
- (b) Utilizing location quotients, where data on output and exports were not available.
- (c) Using the nature of the industry, e.g. finance and local government are locally-oriented, and hotel and federal government are export-oriented.

From the data thus constructed, equation (3.3.3) was estimated as

$$L = 0.07 + 0.224T \qquad r^2 = 0.81$$

The value of the employment multiplier is therefore 1.29 $(= \frac{1}{1 - 0.224})$ for the state of Hawaii.

3.3.2 Regional Social Accounting Models

In this section, we will present three of the existing RSAM. As described earlier in Chapter Two, RSAM are aggregative, multi-sectored (rather than two-sectored as in REBM) national-income determination models of the Keynesian lineage. Behind this Keynesian framework is a set of income and product accounts.

Each of the three RSAM which we are about to describe has been developed on a set of income and product accounts, although it must also be mentioned that the way in which the set of accounts was developed differs from model to model. The first RSAM to be described is the Puerto Rico model. In this model, a full set of income and product accounts was available. Then we will describe the Ohio model which has been developed on an *incomplete* set of income and product accounts. The last model we will describe in this section is the Illinois model. A system of regional social (income) accounts was developed to implement this model by allocating a share of the components of the National Income and Product Accounts for the United States to Illinois. We will now discuss each of these three existing RSAM in turn, first beginning with the Puerto Rico model.

(a) The Puerto Rico Model¹⁴

Puerto Rico is a semi-autonomous region of the United States with strong trade ties with the "mainland". Because of her political relationship of "free association" with the United States,

14. N. Dutta and V. Su [82].

".....free trade, free flow of capital and unrestricted migration of population (occur) between the two".^{14a} This particular relationship between Puerto Rico and the United States, therefore, justifies our treatment of Puerto Rico as a region of the United States (see our definition of a 'region' in Section 1.1 in Chapter One) and our inclusion of the Puerto Rico model as a regional econometric model in the present discussion.

The model has twenty-three stochastic equations which explain six categories of consumption expenditures, three types of output, three exports, eight import components, two investments, and one wage share. The model concentrates on the following five main sectors of the economy: consumption, investment, exports, imports, and production. Government sector activity is taken to be exogenously determined.

Six categories of consumption expenditures have been explained by the model. For food, services, and non-durables, the usual consumption function is assumed although some demographic variables are also included. Thus, in addition to disposable income, family size and population are used to explain expenditures on food and on services respectively. For expenditures on housing, automobiles, and durables, a distributed-lag formulation is adopted which after a Koyck-type transformation reduces to the following form:

$$C_t = aY_t + \lambda C_{t-1}, \text{ where } a \text{ and } \lambda \text{ are parameters.}$$

Total investment has been split into three categories: inventory change, other private investment, and government investment. Government investment is considered to be exogenously determined. Inventory change is explained simply by changes in income. Other

^{14a} Ibid., p.319.

private investment which consists mainly of foreign investment (from U.S. investors) has been regressed on the level of take-home profit MS_2 of the foreign investors and on gross product GP. The explanatory variable MS_2 is used as a proxy for the current level of profit on foreign investment and the second variable GP as a proxy for the influence of economic outlook on investors. So the two explanatory variables when taken together serve as a proxy for the total effect both of the current level of profit and of expected profit on the investment pattern.

Total exports has been split into three groups: traditionally traded commodities X_1 , non-traditionally traded commodities X_2 , and service exports X_3 . Three explanatory variables have been used to explain each group of exports. They are the U.S. expenditure on the related commodities CUS, the U.S. price index for the same group of commodities PUS, and the output of Puerto Rico in its related sector Q_1 . CUS is used to proxy for the income of the importing country. PUS is used instead of the more common relative price ratios or differences between the export price of Puerto Rico and the home price of the U.S. This is so because export prices in Puerto Rico are expected to be very largely governed by U.S. behaviour, and hence the Puerto Rican exporter is considered to be a "price-taker". The last explanatory variable Q_1 is used to represent the effects of the supply constraints on the behaviour of exports.

Total imports has been disaggregated into four classes of consumer goods (food, automobiles, non-durable goods and durable goods); raw materials; investment goods; service payments firstly for investments from the U.S. MS_2 , and secondly for transportation, travel and

miscellaneous MS_1 . In the case of each of the consumer-good categories three imports are regressed on the corresponding consumption expenditure. Imports of durable consumer goods are regressed on the consumption expenditure on durables and on the one-year lagged value of durable imports. Since raw materials are imported to be used as inputs in further production variations in the level of raw-materials imports depend on the level of production. Hence manufacturing production Q_m and production in the other industries Q_r are included to explain raw-materials imports. Imports of investment goods is regressed on total investment and a time trend to represent the growth of such an import. For the remaining two items of imports, the "take-home" profit on foreign investment MS_2 has been regressed on its own lagged value and on gross product; and MS_1 has been regressed on total merchandise imports and on net income. With this, we have completed our discussion of the expenditure-side of the Puerto Rico model. The expenditure components are connected with the "real" side of the model through a production function, and it is this real-side of the model which we will next discuss.

The productive system in the Puerto Rico model has been disaggregated into three sectors: agriculture, manufacturing, and the rest. Total output Q depends linearly on total employment and capital (instead of the usual log-linear formulation). This is done on the basis that the time period under investigation refers to a linear segment of the overall, basic non-linear function. For manufacturing and the "other" outputs, employment in the respective sectors and total private investments ($I_p + I_n$) appear as regressors in the

equations concerned. Total private investments is used instead of the usual capital stock variable because disaggregated capital input data are not available.

On the whole, the Puerto Rico model resembles to a great extent a typical national model with most relationships in the Puerto Rico model specified in much the same way as in most macroeconomic studies. The model has the full benefit of a complete set of social accounts which forms the framework for the "Identities" in the model, e.g. Gross Product is the sum of Consumption, Investment, Government and the Net Foreign Balance. The main weakness of this model lies in the trade relationships. As noted by its authors, the island's economy depends very much on her exports to the United States. Yet, in specifying their export equations, they view the export process as one limited by the supply side of the Puerto Rican economy. Exports are related to Agricultural and Manufacturing Output, Lagged Government Investment and Imports of Raw Materials. Variables representing the United States Economy, i.e., representing demand conditions, do not appear in the export equations. This seems to be a serious shortcoming in a model purporting to represent an economy so closely tied to the United States.

(b) The Ohio Model¹⁵

The Ohio model is an interdependent system consisting of twenty-seven equations of which sixteen are stochastic. The model is made up of five segments: consumption, investment, personal income and federal income tax, outputs by sector, and tax equations. As mentioned earlier (p.53), the Ohio model is developed on the basis of an incomplete set of income and product accounts. The incompleteness is due mainly to the lack of the required statistics. The most important missing data include foreign trade data, consumption expenditure data, investment data (excepting for the manufacturing sector). Hence, no foreign trade sector has been included in the Ohio model. Nor are there a regional consumption function, investment functions for sectors other than manufacturing.

The consumption sector has two equations which explain retail sales less automobiles R and the dollar sales A of new car dealers respectively. Total manufacturing investment is broken down into expenditures for structures $ISMA$ and expenditures for machinery $IMMA$. Personal income is regressed on ΔGSP and GSP . Federal income taxes are regressed on personal income. The output sector consists of equations regressing components of GSP on relevant explanatory variables, some of which are national variables (e.g. GNP). The other explanatory variables are endogenous variables from other sectors of the model. For example, gross state product in trade GSP^{td} is regressed on sales by new car dealers A and retail sales R less A . It is in the output sector of the model that we observe the interaction among

15. W. L. L'Esperance, G. Nestel and D. Fromm [113].

some of the endogenous variables. There are two tax equations in the model which explain the gallons of taxable motor fuel sold in Ohio and the sales tax receipts respectively.

The model has the components of a macroeconomic model, but these are not drawn together in such a way as to represent a consistent structure of the Ohio economy. In particular, the gross state product and the expenditure elements of the model are scarcely related to each other. This characteristic is a major shortcoming in that it is difficult to see in what sense the equations come together to form a model.

But the most important feature of the Ohio model is the inclusion of the various policy variables into the model. Thus the percentage change in the amount of automobile installment credit outstanding in the U.S. ($\Delta AC/AC$) is used to explain sales by new car dealers A in the consumption sector. In the investment sector, interest rates on corporate bonds RCB and interest rate on 90 day Treasury bills $RTBS$ are used to explain $ISMA$ and $IMMA$ respectively. In the output sector, military prime contracts awarded in Ohio MPC is used to explain manufacturing gross products; new housing units authorized in permit issuing places in Ohio HP is used to explain GSP^{cc} gross product in contract construction. Other policy variables included are Ohio's gross state product in federal government GSP^{fg} and in state and local government GSP^{slg} . The inclusion of such policy variables into the model greatly facilitates the job of policy evaluations. Thus the effect of a certain percentage change in any one of the policy variables on the set of regional variables can be evaluated by solving simultaneously the equations in the model. However, some criticisms have been levelled at the nature of the policy variables included.

It has been argued that some policy variables such as MPC, RCB, and RTBS are beyond the control of the Ohio state government and are hence not genuine policy variables.

(c) The Illinois Model¹⁶

In this model, the different economic activities of the Illinois economy are represented by a system of fourteen relationships which include twelve behavioural equations and two identities. The endogenous variables (i.e. those explained by the model) include gross state product GSP, five expenditure components (consumption C, business and residential investments IB and IR, state and local government purchases G, and the unallocated component (net exports) E), total personal income PI, disposable personal income DPI, personal income tax collection PT, and five state tax revenues (property TP, sales TS, tobacco TT, gasoline TG, and alcohol TA). The fourteen relationships of the model are estimated for the period 1929-1963 using annual data. The model is then turned into its reduced form to be used for both forecasting and for policy evaluation purposes. In the first application, the model is used to give projections of economic growth in the state between 1970 and 2010 (hence a long-range projection). Since the main objective of the model is concerned with the growth in aggregate demand at the state level, the projected variables are components of final demand, such as consumption expenditures, investment (both business and residential), and gross state product. In addition, several revenue variables representing sales tax collections, property taxes, and other

16. R. J. Green [23].

commodity taxes, are projected. These latter projections are obtained for the second application of the Illinois model to estimate the impact on the Illinois economy of various policy alternatives which are under the control of the state government. The projections show, for example, the effect of changes in various state tax rates on the growth of the state, and also the effect of the imposition of a flat rate income tax.

The Illinois model also explains five state tax revenues (property tax, sales tax, tobacco tax, gasoline tax, and alcohol tax), again using the general form (3.3.5) in most cases. The most important explanatory variables in the state tax equations are the various state tax rates. These are the policy variables in the Illinois model and they play an important role in the policy evaluation application of this model. By incorporating these state tax rates into the model, the model-builder can then investigate the impact on the Illinois economy of changes in these tax rates.

3.3.3 Regional Production Function Models

In this section, we will present three of the existing RPFM. As described in Chapter Two, Section 2.3.2c, the main features of RPFM include, firstly, that they pay more attention to the supply side of the region and less attention to aggregate demand and its components, the latter being the main concern in RSAM. Secondly, RPFM are long-run growth models very similar in some respects to the national econometric models of the Solow-type.¹⁹ But RPFM differ from these national growth models in that they employ quite a different concept (mechanism) of regional growth. In the three existing RPFM to be discussed, the first two models (the Massachusetts model and the Philadelphia model) rely on the simple economic base theory to explain the phenomena of regional economic growth whereas the last model (the Nova Scotia model) explains these phenomena by location theory. We will now describe each model in turn, first beginning with the Massachusetts model.

(a) The Massachusetts Model²⁰

The model consists of eight stochastic equations and six definitions and identities making a total of fourteen equations. The model is used to predict regional economic growth, and consists of

19. See R. M. Solow [132] and P. E. Smith [131].

20. F. W. Bell [72].

three major segments: a series of hypotheses to explain the total income received and therefore the total output in the state of Massachusetts, specifications relating investment expenditures to levels of output in the manufacturing and non-manufacturing sectors, and behavioural specifications to explain the state's labour supply and demand, and rate of unemployment.

The first segment of the model relates to income generation in the region. The simple "export base" theory, according to which regional economic growth depends largely on the region's ability to export products and hence derive income from "outside" the region, is used to explain regional economic growth. The remaining sectors of the regional economy (called the service sector) derives income from the region's own activities. Thus export income X is regressed on GNP as

$$(3.3.6) \quad X_t = a + b \text{ GNP}_t,$$

and the local service income S is related to the total "received" income V_1 as

$$(3.3.7) \quad S_t = c + d(V_1)_t,$$

where a , b , c , and d are parameters. Total received income is by definition given by:

$$(3.3.8) \quad (V_1)_t = X_t + S_t.$$

In equation (3.3.6), the variable (GNP) is used to represent all sources of export incomes which may include income from product sales, capital income from foreign investment and various transfer payments from the federal government. Total received income V_1 in equation (3.3.7) is used as a proxy variable for the ability of the region to consume local services. Thus given GNP, export income X is determined which helps to determine service income S and hence total received regional income.

The second segment of the Massachusetts model shows the relationships between regional investment and output in both the manufacturing and non-manufacturing sectors. According to the model, the manufacturing sector is the export sector, and the non-manufacturing sector is the service sector. The investment functions for both sectors are of similar form and have been derived from two hypotheses. The first hypothesis states that the percentage increase in the capital stock during the year is a fixed proportion, g , of the percentage gap between the desired stock K_t^* and the actual stock K_t . This may be represented by the following equation:

$$(3.3.9) \quad (K_t/K_{t-1}) = (K_t^*/K_{t-1})^g \quad (0 < g \leq 1)$$

The second hypothesis states that the desired capital stock is a log-linear function of regional output and the level of technology, the latter variable being represented by a time trend t . Thus the second hypothesis can be represented as

$$(3.3.10) \quad (K_t^*) = f(V_2)_t^m (1+p)^{-t}$$

where f , m , p are parameters and V_2 is the region's output (or total produced income in the region).

Since it has been shown by Borts²¹ that the ratio V_2 to V_1 is always a constant, V_2 in equation (3.3.10) is replaced by V_1 to give

$$(3.3.10') \quad (K_t^*) = f(V_1)_t^m (1+p)^{-t}$$

Substituting equation (3.3.10') into equation (3.3.9) we have the following investment function:

$$(3.3.11) \quad (K_t/K_{t-1}) = f^g(V_1)_t^{gm} (1+p)^{-gt} K_{t-1}^{-g}$$

Taking the manufacturing sector as the export sector and the non-manufacturing sector as the service sector, we can substitute export income X and service income S for V_1 in equation (3.3.11) to arrive at the investment functions for the two sectors:

$$(3.3.11') \quad (K_t/K_{t-1})_m = f'^{g'}(X_t)^{g'm'} (1+p')^{-g't} (K_{t-1})_m^{-g'}$$

$$(3.3.11'') \quad (K_t/K_{t-1})_{nm} = f''^{g''}(S_t)^{g''m''} (1+p'')^{-g''t} (K_{t-1})_{nm}^{-g''}$$

Given that X_t and S_t are determined in the first segment of the model, $(K_t)_m$ and $(K_t)_{nm}$ can be determined by equations (3.3.11') and (3.3.11'') respectively.

21. G. H. Borts [3].

Finally a Cobb-Douglas production function with a shift parameter representing neutral technological progress is formulated to relate the gross regional output V_2 to capital- and labour-input services. This regional production function is as follows:

$$(3.3.12) \quad (V_2)_t = A(1+r)^t K_t^h L_t^{1-h}.$$

The last segment of the model determines labour supply, labour demand, and the unemployment rate. Actual supply of labour is defined as the sum of the expected supply of labour and the change in population due to migration. Given the size of the population P , the expected supply of labour N_e is calculated by applying a constant participation rate to P . Net migration at time t is regressed on the last period difference between N_e and L (the demand for labour). The demand for labour cannot be determined until the real wage rate W is determined. This can be seen as follows. By differentiating the production function (equation (3.3.12)) with respect to labour, we have the marginal physical product of labour MPP_L given by:

$$(3.3.13) \quad MPP_L = A(1-h)(1+r)^t \left(\frac{K}{L}\right)_t^h.$$

Assuming profit-maximization under perfect competition the real wage rate W equals MPP_L and is hence given by:

$$(3.3.14) \quad W_t = A(1-h)(1+r)^t \left(\frac{K}{L}\right)_t^h$$

Solving equation (3.3.14) for L , we obtain the equation for labour demand as:

$$(3.3.15) \quad L_t = \left[\frac{A(1-h)(1+r)^t K_t^h}{W_t} \right]^{1/h}.$$

After estimating the production function (equation (3.3.12)), all parameters on the right hand side of equation (3.3.15) are determined except W_t .

There are various theories concerning the behaviour of money wages at the regional level. The most important one is the Phillips' hypothesis which states that the rate of change of money wages responds negatively to both the level and the change in the unemployment rate. If the Phillips' hypothesis is valid at the regional level, then there will be a "feedback effect" of unemployment on the behaviour of wages, and in turn on labour demand. However, if the Phillips' hypothesis can be rejected, we may conclude that regional unemployment is essentially frictional, or that any disequilibrium in the regional labour market has been eliminated through migration. Various forms of the Phillips' hypothesis are tested in the Massachusetts study but the results are all found to be negative. Hence it is concluded that regional money wage rates are quite unresponsive to market forces. Real wages are then postulated to increase secularly on the basis of technological change and capital-labour substitution and exhibit no pronounced reaction to unemployment. The real wage is hence made a function of time:

$$(3.3.16) \quad W_t = B(1+w)^t.$$

Once W_t is determined by (3.3.16), labour demand can be calculated by equation (3.3.15). The difference between the actual labour supply and the demand for labour gives unemployment.

Apart from the three income determination equations, the model deals with the state's production, investment, population, labour supply and labour demand functions. Hence, in a sense, it represents a miniaturization of the national growth models.

There is one interesting feature of the model, however, and this is that its forecasts depend almost entirely on trends in U.S.

Gross National Product since the endogenous variables in it are either determined directly by GNP or by other variables which have been determined by GNP. There is no simultaneity among the endogenous variables. This may have the virtue of being simple, but does not explain important interactions among local variables.

In addition, with the exception of the Investment, Wage and Migration equations, the model gives little more information than an economic base model.

(b) The Philadelphia Model²²

The model is made up of twenty-six equations of which seventeen are structural equations. The model contains two blocks: the "main-block" with fifteen equations, and the "government-block" with only two equations. Within the main-block, the equations determine simultaneously various activities relating to gross regional product, employment, population, prices and wages, and personal income. Personal income, being determined by equations in the main-block, is then used to explain the level of government expenditures which is one of the two endogenous variables in the government block. Thus activities in the main-block help to determine activities in the government-block but not vice versa. In this sense, the model is "block-recursive".

In several ways, the Philadelphia model resembles the Massachusetts model which we have already described. For this reason, it is appropriate to compare the two models. Both models have been used to predict regional economic growth by incorporating the simple "export-base" theory into the model. In both cases, the manufacturing sector is taken to be the export sector and the remaining sectors taken together constitute the service sector. The national variable, GNP, is related directly to the output (or income in the case of the

22. N. J. Glickman [88].

Massachusetts model) of the export sector and personal income (or total received income) is used to explain the service sector's output. Regional growth is then explained in the following way. The growth of GNP determines the growth of export income (or output) which, in turn, determines the growth of local income.

The two models are similar in other respects, also. Both models focus on the supply side of the economy. Like the Massachusetts model, the Philadelphia model has an investment function, wage equations, and equations for labour demand, labour supply, population, and net migration. Unlike the Massachusetts model, however, it has no production function; instead it has a consumption function and a price equation. The Philadelphia model also has a small government sector.

In the Philadelphia model an investment function is formulated for the manufacturing (export) sector. Instead of the more complicated log-linear formulation adopted in the Massachusetts (henceforth M.) model, a linear function is adopted to explain investment in terms of capital stock, output, and lagged investment. In determining the size of the labour force L , the two models follow different procedures. Instead of L being calculated by applying a constant participation rate to the population figure as is done in the M-model, the Philadelphia (henceforth P.) model explains L by total employment E and "time". The rationale behind this formulation is that L is influenced by employment opportunities (proxied by E) and migration (proxied by "time"). Labour demand (or Employment) equations also differ in the two models. In the P-model, employment equations are essentially inverse forms of the simple production function.

This is not the case in the M-model. Like the M-model, the framers of the P-model have tested various formulations of the Phillips' hypothesis in explaining regional wages. The same negative result has been obtained and the regional Phillips' hypothesis has been rejected. The P-model then explains the average money wage rate in the region by an empirical formula relating the regional level of unemployment and the national wage rate to the regional wage rate. Consumer prices are determined in the P-model as a function of average unit labour costs and total employment. The use of the former explanatory variable implies a pricing scheme in which firms set prices as a mark-up over unit labour costs. The inclusion of the latter variable E in the price-equation represents cyclical patterns in price-setting.

The most serious weakness, for policy purposes, of the M-model is the omission of the government sector. This point has been improved on by the P-model by including a "small" government sector. Nevertheless, due to data limitations, only total (local) government revenues and government expenditures have been explained by the two equations concerned in the government-block. Wherever possible, it seems to be desirable to include more government equations in the model. The other weakness of the P-model is its lack of "feedback" effects from the government-block to the main-block. Thus the government's activities could not affect the variables in the main-block. For this reason, no government multiplier can be calculated.

(c) The Nova Scotia Model²³

This is another model developed for the special purpose of studying regional economic growth. But unlike the previous two RPFM (the Massachusetts model and the Philadelphia model) which explain regional growth by the simple economic base theory, the Nova Scotia model explains the growth phenomenon by location theory. As argued by the authors of the Nova Scotia model, regional growth does not take place as the result of increasing export demand but rather through new productive investment (i.e. new job-creating investments). An open region is thus viewed primarily as a place competing with all other places in the nation in efforts to attract new investments, and since these new investments take place on the basis of individual location decisions of entrepreneurs, the model concentrates on factors which affect the locational decisions of entrepreneurs. Hence, the core of the model is based on investment functions which try to determine the effects of various locational factors upon the attractiveness of the region for investments in new productive facilities.²⁴

The Nova Scotia model is comprised of fifty-four equations of which thirty-one are structural, five are balancing, and the remaining eighteen are definitional equations. There are 104 variables in the model including 54 endogenous variables and 50 predetermined variables. There are eight target variables included among the endogenous variables and also eight instrument variables included among

23. S. Czamanski [12].

24. For a more detailed discussion of this hypothesis, see Czamanski, *Ibid.*, Chapter 3, pp. 16-24.

the predetermined variables. This model is, therefore, the largest of all the REM included in our survey. The model is divided into seven sub-models, namely: (1) Iron and Steel Industry; (2) Manufacturing and Employment; (3) Output and Investments; (4) Households; (5) Governments and Trade Deficit; (6) Population and Migrations; and (7) Welfare. The seven sub-models differ from each other in degree of complexity and in the number of equations. Because of the large size of the Nova Scotia model, we will not discuss all the seven sub-models, but rather we will describe only the Manufacturing and Employment sub-model which, from several points of view, is regarded by the original authors as the most significant.²⁵

This sub-model is comprised of seven equations and two identities. It deals with two closely related problems: total employment in the regional economy and developments in the manufacturing sector (which is the most important sector of the Nova Scotia economy). Total employment equals the sum of employment in agriculture, forestry and fisheries; mining; manufacturing; commercial services; governments; and in the iron and steel industry. Of the six basic components of employment in the regional economy, two, namely employment in mining and in the primary iron and steel industry "... are largely determined by political and not by economic considerations".²⁶ Consequently, they have been treated throughout as data variables. By contrast, employment in agriculture, forestry and fisheries; commercial services; and by governments, including military personnel, are taken to depend

25. See Czamanski, *Ibid.*, p. 24.

26. *Ibid.*, p. 71.

upon developments in the Nova Scotia economy and have been dealt with by separate equations. Employment in agriculture, forestry, and fishing has been explained as a function of commercial farming while employment in commercial services has been explained as a function of the degree of urbanization as represented by the variable total urban population in Nova Scotia. Employment in governments has been explained as a function of military expenditures which is an instrument variable.

With respect to manufacturing, "... the general paucity and low quality of data precluded the successful estimation of a production function of a conventional type."²⁷ Instead, value added in manufacturing is explained as a function of capital stock and of average size of plant. The determination of capital invested in manufacturing hinged upon a successful estimation of an investment function.²⁸ Investment in manufacturing has been explained as a function of government investments in infrastructure such as power plants, transportation facilities, and industrial estates, and of an accessibility index. This last variable refers to changes in accessibility to centres of manufacturing activity in Canada, in accessibility to population centres, and to the tonnage handled in Halifax harbour.²⁹ Both explanatory variables were taken with a four-years' lag.

27. *Ibid.*, p. 72.

28. This is so because capital invested in manufacturing at the end of the current period is equal to total capital in existence in the previous period and investments made in that period.

29. This variable is taken as one of the locational factors which attract entrepreneurs to invest in manufacturing in accordance with the location theory. For details, see Czamanski, *Ibid.*

Finally, exports of manufacturing products have been explained in terms of demand in the rest of the country, measured by GNP, and of the competitive ability of Nova Scotia manufacturing production as represented by the difference in price levels for manufactured products in Canada and Nova Scotia (c.f. export equations in the Philadelphia and in the Massachusetts model).

Notice that there are nine endogenous variables and nine equations in this sub-model. The system is diagonally recursive,³⁰ a feature which enables it to be estimated by ordinary least squares.

Production and investment functions have also been estimated for other sectors besides the manufacturing sector using the same approach which is essentially to treat the sector from a "supply" point of view. Consumption functions and, generally speaking, a study of demand forces play only a subsidiary role in the Nova Scotia model.

By incorporating both the target and instrument variables, the Nova Scotia model can be used either in policy analysis or in planning as well as for forecasting regional growth.

3.3.4 Regional Input-Output Models

As we concluded in Chapter Two, Section 2.4, the main use of RIOM is in regional planning. Having specified the targets and the instrument variables, and set up the inter-industry (or inter-sectoral) structure of the regional economy in a regional input-output table, decisions as to the appropriate instruments to be used to achieve a certain target (or targets) can be made by solving the RIOM.

30. See Czamanski, *Ibid.*, pp. 55-58, for an exposition of this model feature.

The inputs are values of the specified targets while the outputs give desired values for the instrument variables (see Section 2.3.2d). Also recall that in connection with regional planning (Section 2.2), we have described both the "fixed" target approach to planning originally expounded by J. Tinbergen and the "flexible" target approach expounded by H. Theil.

Both of the RIOM which we are about to describe were developed for use in regional planning. The first (the Oahu, Hawaii model) follows the "fixed" target approach, i.e. fixed values of the targets are fed into the model which is then solved to give estimates for the instrument variables. The second model (the New Mexico model), on the other hand, follows the "flexible" target approach in that an objective function is established and then maximized by the optimizing technique of linear programming. We will first present the Oahu, Hawaii model.

(a) The Oahu, Hawaii Model³¹

This model is developed for economic planning and growth for the island of Oahu, Hawaii. The novel feature of the Oahu, Hawaii model is that it attempts to quantify and integrate planning goals (or targets) within the model itself. In other words, the model projects economic growth and the types and levels of certain kinds of exogenous spending necessary to achieve four planning goals. These goals, specified in quantitative terms, are related to the shape of income distribution, to desired levels of population, to external payments outside the island, and to the combined budgets of state and local

31. R. Artle [70].

government agencies. For example, not only does the model predict total incomes but distributes these incomes among three household categories - low-income, middle-income, and high-income households. Labour demands from the industrial, household, and government sectors are also divided into three groups - demands for skilled, unskilled, and medium-skilled labour - with income used as a proxy measure of skill levels. No discussion is provided, however, on how the planning goals themselves were derived.

The local economy was conceived of as a household sector plus sixteen industry sectors including a service sector and state and local expenditures (excluding public investment spending). The driving force of the local economy was exogenous spending divided into four categories: (1) federal defense spending in Oahu, (2) tourist expenditure in Oahu, (3) research and development expenditures in Oahu, and (4) public and private investment in Oahu. Instead of assuming certain levels of exogenous spending to drive the local economy, this model assumes certain planning goals and then derives as an output the levels of exogenous spending in these four categories necessary to achieve the planning goals.³² Now we will describe the Oahu model in more detail.

Let there be n industries. The demand for the output of the i^{th} industry, D_i , is the sum of consumers' demand, C_i , investment demand, I_i , government demand, G_i , foreign demand, E_i , and the intermediate demand of other industries, X_i , such that

32. Recall that in Chapter Two, we have stressed the point that planning models operate in a reverse way to policy models. See Section 2.2.

$$(3.3.17) \quad D_i = C_i + I_i + G_i + E_i + X_i \quad (i = 1, 2, \dots, n).$$

Consumers' demand for commodity (i) is assumed to be a function of total consumption C such that

$$(3.3.18) \quad C_i = c_i' C$$

Total consumers' expenditure is assumed to be a function of current disposable income so that

$$(3.3.19) \quad C = c'(1 - t_f - t_s - t_\ell)Y,$$

where c' is the propensity to consume out of disposable income and t_f , t_s , and t_ℓ are the proportions of income paid in federal, state and local taxes. As for the remainder of their incomes, consumers allocate them to purchases from other consumers (domestic service and rent) and to imports. Both of these are expressed as functions of disposable income, with savings treated as a residual.

The next two components of demand for commodity i are investment demand and government demand. Each is assumed to be a portion of the relevant aggregate magnitude:

$$(3.3.20) \quad I_i = q_i I$$

$$(3.3.21) \quad G_i = G_i^{ND} + G_i^D = g_i G^{ND} + g_i' G^D,$$

where I is total investment, G is total government spending and the superscripts ND and D denote "non-defense" and "defense" respectively.

Foreign demand can be divided into two components: tourist expenditures, V , and commodity exports. Tourist demand for industry i 's output is assumed to be a fraction of total tourist expenditures:

$$(3.3.22) \quad V_i = v_i V.$$

For all but three industries (sugar, pineapple, and apparel) the demand for commodity exports is assumed to be a constant portion of the industry's output, Z_i , so that

$$(3.3.23) \quad E_i = e_i Z_i.$$

Exports of sugar, pineapples, and apparel are treated as exogenous.

The last component of demand is X_i , intermediate demand. Under the usual assumption of an input-output model, intermediate demand for commodity i is the sum of the demand of each industry for commodity i such that

$$(3.3.24) \quad X_i = \sum_j x_{ij}$$

where $x_{ij} = a_{ij} Z_j$.

Since data on the matrix of coefficients $[a_{ij}]$ were not available, the model introduces a set of assumptions to help construct $[a_{ij}]$. The estimates of the coefficient a_{ij} are obtained in one of two ways depending on the industry. For some industries (sugar, pineapple,

agricultural products and mining) the coefficients were estimated by surveys. For the other industries, the parameters were estimated by a method which is very similar to the use of "location quotients".³³

Equilibrium in each of the commodity markets requires the equality between supply and demand. The supply of commodity i is divided into local production, Z_i , and imports, M_i . It is assumed that imports of commodity i is a function of the local output of the commodity:

$$(3.3.25) \quad M_i = m_i Z_i.$$

We can now express the equality of supply and demand for each commodity by

$$(3.3.26') \quad Z_i + m_i Z_i = c_i' [c' (1 - t_f - t_s - t_x)] Y + q_i I + g_i G^{ND} \\ + g_i' G^D + v_i V + e_i Z_i + \sum_j a_{ij} Z_j + E_i,$$

or

$$(3.3.26) \quad Z_i = c_i Y + q_i I + g_i G^{ND} + g_i' G^D + v_i V + (e_i - m_i) Z_i \\ + \sum_j a_{ij} Z_j + E_i.$$

It is to be understood that $e_i = 0$ in the above expression (3.3.26) for sugar, pineapple, and apparel and that $E_i = 0$ for all other industries.

33. For a discussion of the "location quotients" method of identifying the economic base, see Section 2.3.2a in Chapter Two, and Section 3.3.1 in this chapter.

Of the variables appearing in the right hand side of (3.3.26), consumers' income, Y , is not a truly exogenous variable. It is composed of incomes received by households for services performed for industry and for government:³⁴

$$(3.3.27) \quad Y = \sum_j Y_j + Y_g.$$

Payment by industry to households is assumed to be a function of output:

$$(3.3.28) \quad Y_j = w_j Z_j,$$

and income generated by non-defense expenditures G^{ND} is similarly related to government payrolls:

$$(3.3.29) \quad G^{ND} = aY_g$$

Next, it is assumed that incomes received from government can be expressed as a linear function of incomes received from industry:

$$(3.3.30) \quad Y_g = b + d \sum_j w_j Z_j.$$

Combining (3.3.29) and (3.3.30) gives

$$(3.3.31) \quad G^{ND} = ab + ad \sum_j w_j Z_j.$$

34. Notice that households', transfer payments, and incomes from foreign sources were ignored in our discussion.

Using equations (3.3.28) and (3.3.30) to substitute for incomes, and equation (3.3.31) to substitute for the non-defense portion of G in equation (3.3.26), we obtain

$$\begin{aligned}
 (3.3.32) \quad Z_i = & c_i \left(\sum_j w_j Z_j + b + d \sum_j w_j Z_j \right) + g_i (ab + ad \sum_j w_j Z_j) \\
 & + (e_i - m_i) Z_i + \sum_j a_{ij} Z_j + g_i' G^D + q_i I \\
 & + v_i V + E_i.
 \end{aligned}$$

Equation (3.3.32) expresses the equilibrium condition for each of the commodity markets, and from this it follows that the equilibrium of the commodity markets as a whole can be expressed as a system of simultaneous equations:

$$\begin{aligned}
 (3.3.33) \quad [Z] = & [A][Z] + (1 + d)[c][W][Z] + ad[g][W][Z] \\
 & + [e - m][Z] + [q]I + [v]V + [E] + [g']G^D \\
 & + [c]b + [g]ab.
 \end{aligned}$$

where $[Z]$ is an $(n \times 1)$ vector of outputs Z_i ,

$[A]$ is an $(n \times n)$ matrix of input-output coefficients a_{ij} ,

$[c]$ is an $(n \times 1)$ vector of consumption coefficients c_i ,

$[W]$ is a $(1 \times n)$ vector with elements w_j ,

$[g]$ and $[g']$ are vectors $(n \times 1)$ with coefficients g_i and g_i' ,

describing the distribution of non-defense and defense expenditures,

$[e - m]$ is an $(n \times n)$ diagonal matrix whose elements are

$$(e_i - m_i),$$

$[q]$ and $[v]$ are $(n \times 1)$ vectors describing the distribution of investment and tourist expenditures,

$[E]$ is an $(n \times 1)$ vector of exogenous exports, with non-zero elements only in the rows corresponding to sugar, pineapple, and apparel,

and the remaining symbols represent scalars.

Collecting terms, equation (3.3.33) can be rewritten as

$$(3.3.34) \quad [Z] = [B][Z] + \{[c]b + [g]ab + [g']G^D + [q]I + [v]V + [E]\},$$

where $[B]$ is an $(n \times n)$ matrix defined as

$$[B] = [A] + (1 + d)[c][W] + (ad)[g][W] + [e - m].$$

The equilibrium level of output Z_i^* for each of the industries can be rewritten as a linear function of the levels of the exogenous variables:

$$(3.3.35) \quad [Z^*] = [I - B]^{-1}\{[c]b + [g]ab + [g']G^D + [q]I + [v]V + [E]\}.$$

The next step is to introduce targets into the model which results in the addition of more subsidiary relationships, and after a

series of premultiplications of the two sides of equation (3.3.35) and eliminations, a smaller system of equations is obtained which is then used to solve for the instrument variables in terms of the target and data variables.

In general, by introducing an interindustry framework the behavioral content of the model has been bounded rather severely. The model does have a particularly important advantage, assuming that the necessary data are available. In many, if not most, applications of regional models the resources for constructing and implementing the models are quite limited. Further, the relevant policy questions facing regional decision-makers are often concerned with industry structure. A large regression model and an input-output study are often out of the question, but forecasts and analysis of industrial structure are desired. In situations of this sort, which are probably quite common, models similar to the Gahu Model could provide a great deal of useful information.

(b) The New Mexico Model³⁵

This is a dynamic linear programming model used in regional planning for the state of New Mexico in the U.S.A. The main purpose of the New Mexico model (henceforth abbreviated as NM model) is for devising regional policies, *via* the solutions of the dynamic linear programming model, that will reduce the social costs of adjusting the regional economy to such exogenous shocks as fluctuations in federal government expenditures, in regional exports, and in externally financed investments in the region. To achieve this, the NM model is designed not only for impact studies but also for identifying the optimal responses of the New Mexican economy to these shocks. In the first application (i.e. impact studies), the structure of production is assumed to be unchanging within the sample period by assuming fixed technical coefficients, and the impact on the endogenous sectors of changes in the exogenous sector is evaluated by inverting the input-output table which is constructed for the NM model.³⁶ In its second application, the NM model is made dynamic by relaxing the fixed technical coefficients assumption and allowing them to be redefined

35. F. L. Colladay and A. D. Sandoval [89].

36. For a discussion on this application of a RIOM, see Chapter Two, Section 2.3.2d above.

each period so that the structure of production can be revised each period in response to changes in the exogenous shocks, and in this way the optimal responses of the New Mexican economy can be identified.

Like any other linear programming model, the objective of the NM model is to maximize some linear function, i.e. the objective function, subject to a set of linear constraints. The objective function of the NM model is to maximize total gross state product which is defined as the sum of the final demand components of consumption, investment, government purchases, and foreign sector purchases. The maximization of this objective function is subject to a set of constraints. Firstly, capacity constraints are imposed on some of the final demand components which are included in the objective function to indicate the maximum possible values allowed for those demand components. Thus the values of exports, private consumption and purchases by state and local governments are constrained to a value below some maximum values.

The maximization of the objective function is also subject to some resource constraints to indicate that resources employed in the New Mexican economy cannot exceed the total that is available. These include constraints regional production by supplies of intermediate resources, capital constraints (i.e. capital services to be employed in production cannot exceed total capital available), constraints on labour used in production to below total labour supply, and the savings-investment constraints. Interregional flows of resources are also constrained by an accounting constraint on interregional trade.

In all, the estimated model contains 342 constraints in 487 variables. The economy is represented by 17 endogenous sectors and three exogenous sectors (state and local government, federal government and household services). Three labour skills are also distinguished.

In the first application of the NM model, the technical coefficients are fixed and a basic solution to the model is used to identify any undesirable bottlenecks in the New Mexico economy such as the shortage of skilled and unskilled labour in particular industries, the lack of effective demand for certain local production, etc., when the actual changes in the exogenous variables are used. This application allows the model builder to identify the static impact on the regional economy of changes in the exogenous factors.

The second application of the NM model enables its model-builder not only to identify static impact but also to identify the most desirable responses of the regional economy to changes in the exogenous factors. The NM model is now made dynamic by allowing the technical coefficients to be revised each period in response to changes in the exogenous factors. The "most-likely" changes in the value of the exogenous variables are now used and the most desirable responses in the various sectors of the regional economy are identified. From this second application it is found that the social cost to the New Mexican economy of a reduction in exogenous factors can be mitigated by revision of the structure of production, and by reallocating the (scarce) labour and capital resources to different sectors. Thus by allowing these "adjustments" in the model, and by examining the

optimal adjustments in different sectors of the regional economy the NM model can be used in devising policies for mitigating the social cost to the New Mexican economy of a reduction in the exogenous factors.

CHAPTER FOUR
A FEASIBILITY STUDY OF THE TASMANIAN ECONOMY

4.1 Introduction

Recall that in the foregoing two chapters, we reviewed a sample of regional econometric models. Chapter Two gave a general account of the common uses, and the various types, of REM that have appeared in the literature in recent years. Having discussed the uses and types of REM separately in different sections of Chapter Two, we then considered the different types of REM in relation to each particular use. This was done in the last section of Chapter Two. The main purpose of this last section of Chapter Two was, of course, to help to identify the best possible use of a particular type of REM. It must be recalled also that the discussion of Chapter Two was facilitated by the classification of the REM into two major classes: empirical and theory-based. The theory-based REM were further sub-classified into four sub-classes. These sub-classes were labelled respectively Regional Economic Base Models REBM, Regional Production Function Models RPFM, Regional Social Accounting Models RSAM, and Regional Input-Output Models RIOM. In Chapter Three, a model-by-model description of the theoretical relationships in each type of REM was given. This was done so as to bring out the finer points of the theoretical underpinning of REM.

Notice also that our previous discussion concentrated mainly on the theoretical and conceptual issues of existing REM. Another, more technical, aspect of regional econometric model-building was not touched upon. This is the problem of getting the required

data to implement a particular type of REM. This becomes a problem when the required data are not available and methods have to be designed to cope with the data shortage. In this chapter, we will pick up this more technical aspect of regional econometric model-building. We want to evaluate the data base of the Tasmanian economy so as to enable us to anticipate insuperable data problems before actually committing ourselves to the construction of one or more of the REM listed above. Viewed in this light, the present chapter can be regarded as a feasibility study of the Tasmanian economy.

The procedure that we will follow to carry out our feasibility study is as follows. Firstly, for each class of REM outlined in Chapter Two, we will pick out the simplest of the existing models, and consider it as a prototype model of that class. Then we will present the structure of each prototype REM in turn. Then we will summarize the data requirements for each prototype REM. Having done this, we will compare these data requirements with the available Tasmanian statistics. When all these steps have been taken, we will be in a position to draw some conclusions as to the feasibility of setting up any particular type of REM for the Tasmanian economy. But before we embark on this procedure, we shall eliminate the Regional Input-Output Models RIOM. We are prepared to say in advance that the construction of an RIOM is not yet feasible in the Tasmanian context because we have as yet no regional input-output table for Tasmania and such a table is the very backbone of any RIOM. Furthermore, the construction of an input-output table is obviously beyond the scope of the present study.

So we are left with the following to be examined:

Regional Empirical Model, Regional Economic Base Model, Regional Production Function Model and Regional Social Accounting Model.

We will consider each of these types in turn, first beginning with the Regional Empirical Model in the next section.

4.2 Regional Empirical Model

Recall that in Chapter Three, we presented the Michigan model (1)¹ as an example of REMM. Since the Michigan model (1) (henceforth to be called Michigan model) is considered as a typical example of REMM, we will also take it as our prototype for this class in the following discussion.

As mentioned in Chapter Three, the Michigan model was designed primarily as a forecasting tool. From this model, a forecast of a set of important regional variables included Michigan's gross state product (GSP) and its major industrial components; retail sales in Michigan, both total and by major types of store; Michigan's labour force, employment and unemployment; and personal income, both total and by major categories. From the results of earlier research,²

-
1. Research Seminar in Quantitative Economics, *op. cit.*
 2. These inquiries took the form of comparing the general behaviour of time series of both the State and national variables for evidence of correlation, common trends, similar pattern of fluctuations, and so on.

workers on the Michigan model concluded that national demand for Michigan's products (that pertaining to the United States) had a significant influence on Michigan economic activity. In particular, they found that national demand for automobiles; national demand for new producers' durables; other national private final demand; and some other national variables played a significant part in explaining the past behaviour of the set of regional economic variables in which they were interested. These national variables were subsequently used as explanatory variables in the Michigan model.

The equations in the Michigan model were estimated in terms of first differences and took the following general form:

$$(4.1) \quad \Delta Y_i = a_i + \sum_{j=1}^n b_{ij} \Delta X_j,$$

where ΔY_i = the i^{th} regional variable, in first differences,
and ΔX_j = the j^{th} national variable, also in first differences.

An example is the equation for GSP:

$$(4.2) \quad \text{GSP} = -0.626 + 0.228 \text{ AUTO} + 0.136 \text{ PD} + 0.08 \text{ OTHER},$$

where ΔGSP = annual change in gross state product,

ΔAUTO = annual change in U.S. demand for automobiles,

ΔPD = annual change in U.S. demand for new producers' durables, and

ΔOTHER = annual change in U.S. demand for other private final products.

Having recalled the structure of the Michigan model, we will now summarize the data that were required to implement this model. It can be seen that the Michigan model, as presented above, employed two different sets of variables. The first was the set of regional variables which included GSP and its major industrial components; retail sales; labour force, employment and unemployment; and personal income. As was mentioned in the Data-Appendix of the model, time series for some of the included regional variables, such as retail sales, personal income, and employment and unemployment, were obtained directly from published information. No published time series was available for GSP for Michigan and this series was estimated by the production method using value-added data.³ The second set of variables used in the Michigan model was the set of national variables which included the national demand for automobiles, for new producers' durables, and for any other private final product. Data for these national variables were again obtained from published sources.

We will now consider the feasibility of implementing a REMM for the State of Tasmania in the light of the above discussion. Like the Michigan model described above, we would use two sets of variables in our model. Further, our regional set would probably consist of variables of the same type as those included in the Michigan model. That is, we would be interested in the behaviour of such regional variables as GSP and its industrial components; retail sales in total

3. See explanatory notes in Appendix, Research Seminar in Quantitative Economics, *op. cit.*

and by types of business; employment and unemployment, and labour force; personal income, both by components and by major industries. On the other hand, it is unlikely that our national set of variables would consist of the same elements as in the Michigan model, the reason being that the economic link between Tasmania and Australia is quite different in nature from that existing between Michigan and the United States. For instance, the industrial structure of the Tasmanian economy differs markedly from that of the Michigan economy. In the case of the Michigan economy, the industrial structure is such that it is heavily concentrated on the manufacturing sector with the result that the State's employment and production are very much dependent on this sector. The industrial structure of the Tasmanian economy, on the other hand, is relatively more balanced in the sense that it is not so much dependent on any particular one of its producing sectors. Because of this difference in industrial structures, and possibly for other reasons, we can expect the nature of the economy tie between Tasmania and Australia to differ from that existing between Michigan and the United States.

As yet, we do not know what Australian variables determine such Tasmanian variables as GSP, employment, personal income, etc. For a clear understanding of the forces at work requires intensive statistical experimentation. At this stage we can only guess at the likely results of such experimentation were it to be carried out. Our guess is that the dominant Australian variables would prove to be GNP, personal consumption expenditure, by commodities and gross private capital formation, by industries.

Table 4.1
Data required for a Tasmanian REMM and the Sources of this Data

<u>Regional Variables</u>	<u>Source</u>
Gross State Product, total and by major industries	not available
Retail Sales, total and by types of business	1 (see below for key)
Employment, total and by major industries	2
Unemployment	2
Population	3
Labour Force	3
Net Migration	3
Personal Income, total and components	4
Personal Income by Major Industries	not available
Disposable Personal Income	4
Personal Tax Payments	4
State and Local Tax Revenue	4

National Variables

Gross National Product	5
Capital Expenditures, by major industries	5
Consumption Expenditures, by major commodities	5

Source:

1. *Retail Sales of Goods*, (CBCS, Hobart.)
2. *Employment and Unemployment*, (CBCS, Canberra.)
3. *Demography*, (CBCS, Hobart.)
4. *Finance*, (CBCS, Hobart.)
5. *Australian National Accounts (ANA)*, (CBCS, Canberra.)

Table 4.1 above draws on the above discussion to give a list of the data required for constructing a REMM for the Tasmanian economy and the sources of such data.

We conclude from this table that the major gaps in the data required for the construction of a Tasmanian regional empirical model are series for GSP and for personal income by major industries. We shall attempt to fill these gaps in Chapter Five. Assuming that we are successful in this attempt it would appear that the construction of a Tasmanian regional empirical model is entirely feasible from the point of view of data requirements.

4.3 Regional Economic Base Model

In this section we will discuss the feasibility of setting up a REBM for the Tasmanian economy. The discussion will follow much the same pattern as in the previous section when we discussed the REMM. Firstly, the structure of our prototype REBM will be presented. Secondly, we will summarize its data requirements. Thirdly, we will compare these data requirements with the obtainable Tasmanian statistics. After going through these steps, we will then draw some conclusions on the feasibility of setting up a REBM for the Tasmanian economy. In the following discussion, we have decided to adopt the Hawaii model which was reviewed in Chapter Three (Section 3.3.1b) as our prototype REBM.

As recalled, the Hawaii model viewed the Hawaiian economy as having only two producing sectors: a basic sector and a non-basic sector. The basic sector, or the economic base of the economy, was conceived to consist of export-oriented industries. These included

both commodity exports (such as sugar and pineapple) and service exports. The hotel industry was one example of the service exports. Federal government purchases, both in the form of defense and non-defense expenditures, were also classified as export-oriented. On the other hand, the non-basic sector was conceived to consist of all locally-oriented industries, that is, those industries which serve only the Hawaiian markets. Finance and Local government purchases were two examples of non-basic industries. As mentioned in the text, the industries mentioned above, "... by their very nature, were classified as export-oriented or locally-oriented industries."⁴ There were other industries in the Hawaiian economy, however, whose classification was not obvious and some method had to be derived for deciding which of the two categories they were to be placed.

Once all industries had been divided into the basic and non-basic categories, the Hawaii model was used to estimate regional multipliers for the Hawaiian economy. These regional multipliers purport to give some measures of the multiplier process which take place in the regional economy as a direct result of an expansion in the export sector of the economy. But before we move on to describe the model used for estimating the regional multipliers for Hawaii, we must first distinguish between two different kinds of regional multipliers. These have been referred to in the literature as income multipliers and employment multipliers respectively. Income multipliers measure the change in total regional income due to changes in export income (or expenditures in the export sector of the economy).

4. See K. Sasaki, *ibid.*, p. 300

They can be computed only when the required regional income data are available. In cases where such income data are not obtainable, employment data are used to compute the economic base-type regional multipliers. The multipliers so computed are called the employment multipliers. Although the two kinds of regional multipliers are computed from identically formulated models,⁵ they measure two different effects of an expansion in the export sector of the economy. The employment multiplier measures the change in total regional employment (jobs) which results from a change in the number employed in the export-oriented industries. Thus defined, the employment multiplier is used to measure the employment effect of an expansion in the export industries, whereas the income multiplier measures the income effect of such an expansion. In the Hawaii model, due to the lack of sufficient income data, only the employment multiplier for the Hawaiian economy was computed. We will now present the mathematical formulation of the Hawaii model.

The Hawaii model estimated the employment multiplier from a regression equation which, in effect, was one of the reduced form equations of the following two-equations model:

$$(4.3) \quad E_T = E_B + E_{NB},$$

$$(4.4) \quad E_{NB} = a + bE_T + u,$$

where E_T , E_B , and E_{NB} were respectively total employment, employment in the basic sector, and employment in the non-basic sector, u was the random error term, and a and b were parameters of this model.

5. This can be seen when one compares the economic base model used in the Hawaii model with that used in the Massachusetts model (Section 3.3.3a, Chapter Three).

The first equation was only a definition which stated that total employment was the sum of both basic and non-basic employments. The second equation expressed the idea that non-basic employment was a linear function of total employment. The reduced form of this model for total employment was given by:

$$(4.5) \quad E_T = \left(\frac{a}{1-b} \right) + \left(\frac{1}{1-b} \right) E_B + \left(\frac{u}{1-b} \right).$$

Notice that E_B , employment in the basic sector, was to be treated as exogenous in the above model. The regression equation used in the Hawaii model for computing the employment multiplier was equation (4.5) above. The least squares estimate of $\left(\frac{1}{1-b} \right)$ in this equation was taken to be the estimate of the employment multiplier.

As mentioned previously,⁶ the implementation of a REBM requires that the industries in the economy be classified as either basic or non-basic in order that the economic base of the regional economy be identified. This will not present any problem in cases where information is obtainable on the destinations of the flow of goods and services for each and every industry in the region concerned. But for most REBM, and this applies also to the Hawaii model, such information is not available. When this happens, the problem of "base identification" will arise and it would become necessary to find some means of deciding which industries are exporting and which other industries are locally-oriented. Three different methods were

6. See our discussion on the Hawaii model in Chapter Three, Section 3.3.1b. See also Chapter Two, Section 2.3.2a on this point.

used in the Hawaii model to tackle this problem. But before we move on to describe the method which was used in the Hawaii model, we will first digress to give a general account of the methods which have been proposed for dealing with the base-identification problem.

The methods which have been suggested for dealing with the base-identification problem are of two types: direct methods and indirect methods. Direct methods of measuring the economic base involve tracing the origins and destinations of commodity and money flows, either from available data or by conducting a survey of consumers and firms.⁷ Undoubtedly, these are the most efficient ways of identifying the economic base. But unfortunately they are also time-consuming and expensive. It is apparent that the direct methods are beyond the resources available to this study and are, therefore, not pursued any further. So we are left only with the indirect methods of measuring the economic base. We will discuss three kinds of indirect methods. They have been labelled respectively the assumption method, the location quotient method, and the minimum requirements method. We will consider each of these in turn.

Of all the indirect methods that we will discuss, the *assumption* method is undoubtedly the simplest. The basis of this method is an assumption (often quite an arbitrary one) as to which industries are exporting and which are locally-oriented. For most REBM which use this assumption method, the assumption usually made is that manufacturing and agriculture are export-oriented while the remaining industries are locally-oriented.⁸

7. For an example of this method of identifying the economic base, see C.M. Tiebout [60].

8. Recall that the Philadelphia model, reviewed in Chapter Three, Section 3.3.3b, employed the assumption method, and the assumption made was that only the manufacturing sector in the region was basic and that the remaining two sectors were non-basic. The Hawaii model which we were describing also used partly the assumption method for identifying the economic base.

Some investigators have tried to justify their use of the assumption method by proposing a more elaborate endogenous-exogenous classification scheme for measuring the economic base. According to such a scheme, an industry is classified as basic whenever the events which determine the activities of this industry can be considered as exogenous to the region concerned. Frequently quoted examples of industries which are basic in this sense are exports of goods and services, and factor payments and transfer payments made from external sources to the residents of the area concerned. These activities (or industries) usually result in an inflow of income to the region, but, as the proponents of the endogenous-exogenous classification scheme argue, the magnitude of such an inflow often depends on events over which the regional community has no control. For this reason, they continue, these activities are governed by events which are exogenous to the region, and they should be classified as basic activities. It follows from this line of reasoning that when events governing the activities are considered as endogenous, then these activities should be classified as non-basic.⁹

The second indirect method that we will discuss is the *location-quotient* method. This method provides one rather widely-used means of measuring the economic base of a regional economy. The underlying notion is simple. If a given region is highly specialized relative to the nation in the production of a particular commodity, then the product is presumed to be an export item. Such a regional

9. On the endogenous-exogenous approach, see for example T. Lane [11]; and S. H. Park [124].

specialization in the commodity is assumed to be reflected in the high concentration of regional employment in that particular industry relative to the national employment in the same industry. The location quotient is a measure of such a concentration. It is the ratio of the employment in a given industry as a per cent of total employment in the regional economy to employment in the same industry as a per cent of total employment in the national economy (or any other benchmark economy). Symbolically, the location quotient (l_i) of industry (i) in region (r) is given by:

$$(4.6) \quad l_i = \frac{E_{ir}}{E_r} / \frac{E_{in}}{E_n} ,$$

where E_{ir} = regional employment in the i^{th} industry,

E_r = total regional employment,

E_{in} = national employment in the i^{th} industry, and

E_n = total national employment.

Calculated values of (l_i) are used to determine whether industry (i) is basic or non-basic. When this value exceeds unity, it is an indication that the i^{th} industry has a higher employment concentration in the region than in the nation. It also suggests that the region is more specialized in its i^{th} industry than the nation as a whole. The conclusion in this case will therefore be that the i^{th} industry in the region is export-oriented, i.e. basic.

Following the above line of reasoning, when the calculated value of (l_i) is less than unity, it would be concluded that the i^{th} industry is non-basic. Once the conclusion regarding the "export status" of the i^{th} industry is reached, the job which remains is to

assign the employment figure in the i^{th} industry into the basic and the non-basic categories. Two schemes of classification exist for this particular purpose. One allots the whole employment figure to either the basic or the non-basic groups, depending on the finding as to the export status of the industry. This scheme, of course, makes the assumption that the i^{th} industry can either export or serve only local markets, but not both. Some industries, however, serve both the external and local markets, and for these industries, the assumption made in the first scheme is obviously not satisfactory. The second scheme of classification takes account of this. So instead of assigning the whole employment figure in the i^{th} industry to either the basic or the non-basic group, as is done in the first scheme, the second scheme apportions this employment figure to both groups. The formula to be used for calculating the basic portion of the employment figure of the i^{th} industry is given by:

$$(4.7) \quad E_{ir}^e = E_{ir} - E_r \left(\frac{E_{in}}{E_n} \right),$$

where E_{ir}^e = the basic employment in the i^{th} industry, and the other symbols have already been defined.¹⁰

There is yet a third indirect method for identifying the economic base, and this is called the *minimum-requirements* method.¹¹ This method begins with a consideration of, say, a hundred or more

10. For an example of this classification scheme, see G. E. Thompson [141].

11. See E.L. Ulman and M.F. Dacey, [144].

regional economies which are similar to the one under study. For each regional economy the per cent of the total labour force employed in each industry is calculated. The percentages for a given industry are then ranked in decreasing order of magnitude. The smallest per cent is taken to be the minimum required by any region to satisfy its own needs. Therefore, all employment in other regions above this amount is considered as export employment. Repeating this process for each and every industry yields total export employment for the particular region under study. For various reasons the minimum-requirements method is not much used in empirical studies of the REBM. One stringent requirement of this method is that one must have a fairly large sample (say a hundred or more) of similar regional economies comparable to the one under study. We feel that this requirement can never be met in our particular study. For if we take the State of Tasmania as the region under study, then it would be impossible to have more than six State economies for comparisons under the existing Australian Constitutional arrangements. For this reason alone, we can safely rule out the minimum-requirements method as a possibility for Tasmania.

Having made the above digression to consider methods of identifying the economic base in general, we will now take up our discussion of the specific methods used in the Hawaii model. It was noted earlier that the investigator of the Hawaii model was able to divide some industries into the basic and the non-basic categories according to the specific nature of the industry concerned. By this means both the hotel industry and the Federal government sector were classified as basic and the finance and Local government sectors as

non-basic. To categorize the remaining industries, where the appropriate classification was not obvious, two different methods were used - one direct and one indirect. In the case of the first method (a direct method) total employment in an industry was divided into export and local components on the basis of the ratio between the value of exports and the total value of output for this particular industry. This method was applied, of course, only to those industries for which data on values of output and exports were available. Manufacturing, construction, wholesale, retail trade, utilities, and agriculture industries were included in this category.

The second method was the location-quotient method as described above, except for one small variation in the definition of the location quotient. Instead of defining the location quotient as the ratio of the two percentages of industry employment to total employment, it was defined in the Hawaii model as the ratio of the two percentages of industry employment to total population. But the earlier definition of the location quotient given earlier appears to be more general and is hence preferred.

With this, we have completed our study of the Hawaii model with specific reference to the data problems which it involved. We will not use this discussion to compare the data requirements for a REBM for the Tasmanian economy with what is available from published information. Then we will make an assessment of the data situation and reach some conclusion on the feasibility of constructing a Tasmanian REBM.

If we were to implement a REBM for the Tasmanian economy similar to the Hawaii model described above, then we would need to

have, firstly, time series for:

- (a) total regional employment
- (b) regional employment according to major industry groups.

Secondly, to permit the division of industry employment into the export and local components, we would require, in addition to the above, the following time series:

for those industries with published information on the value of exports and output:

- (c) the values of exports and output by major industry groups.

for those industries with no such information; and for which the location quotient method is to be used for the division of industry employment into the two categories:

- (d) national employment
- (e) national employment according to major industry groups.¹²

Our next task is to examine our data base to see if we have the statistics which the above discussion suggests would be required to build a REBM for the State of Tasmania.

12.. Notice that we could estimate only the employment multiplier for Tasmania from a REBM so constructed from the above series. If, on the other hand, we wanted to estimate the income multiplier from our REBM we would require income data instead of employment data. The availability of income data for Tasmania will be discussed in a later section in connection with the feasibility of constructing a regional production function model for Tasmania.

The position may be summarized as follows:

(A) From *Employment and Unemployment*, (CBCS, Canberra,) we can extract time series for:

- (a) total civilian employment both for Tasmania and for Australia
- (b) civilian employment by major industry groups both for Tasmania and for Australia.

(B) From *Primary Industries*, (CBCS, Hobart)

Secondary Industries and Building, (CBCS, Hobart)

Trade and Shipping, (CBCS, Hobart)

we can compile series for the value of exports and output both for Tasmanian manufacturing industries and Tasmanian agricultural industries.

We will now summarize the whole data situation in relation to the construction of a REBM for Tasmania. The data specified in A and B above is not ideal. For example, the employment series listed under (b) of A include both private and government employees, and it is difficult to separate the two. Again they exclude rural employment, employment in private domestic service, and employment in the defense forces. On the whole, however, we would not expect to face too serious a data-problem if we set out to implement a REBM for Tasmania so long as we were to content with the estimation of the employment multiplier alone.¹³

13. See footnote 12 above.

4.4 Regional Production Function Model

The third type of REM to be considered in our feasibility study of the Tasmanian economy is the RPFM. This type of REM, like its national counterpart, is supply-oriented. That is, the RPFM is concerned more with such indicators of the regional economy as the level of regional product, and the supply of labour and capital services, than with the region's final demand. This means that an aggregate production function is most essential in the RPFM, for this function provides the link between the level of regional product and the available supply of factor services. It also means that relationships which explain the supply of labour and capital are incorporated in most RPFM. To implement this type of REM, it is generally required to have supply-side data, such as employment; capital stock; and regional product. At the same time, some demographic data, such as population, labour force and participation rates and birth and death rates, may also be required.

Although RPFM are supply-oriented, they are not devoid of demand relationships. These demand relationships often form the basis of a REBM, the role of which in the RPFM is to explain regional economic growth. A REBM which is commonly used in this way consists of three equations. One equation will relate product (or income) originating in the export sector of the region to the nation's gross product. The rationale behind this equation is provided by the economic base theory. According to this theory, regional economic growth depends on the ability of the region to export its products, and this ability is very much dependent on the nation's demand for these products. The variable, GNP, is used in the first equation to

stand for the nation's demand for the regional exports. The second equation in the REBM relates product (or income) originating in the local sector to total regional income. The rationale behind this second equation is also provided by the economic base theory. According to this theory, gross product originating in the local sector depends only on the region's own demand. This region's demand is represented in the second equation by total regional income. The third equation in the REBM is a definition. It simply expresses total regional product (or income) as the sum of products (or income) originating both in the export and in the local sectors of the regional economy. Thus with the incorporation of a REBM of the above type, the RPFM can be used to explain regional economic growth.

The inclusion of a REBM in the RPFM has given rise to additional data requirements. Thus, in addition to the requirement of both supply data and demographic data, it is now required to have income data to implement a RPFM.¹⁴ This income data requirement is often difficult to meet, and constitutes the main data problem in the construction of RPFM. We will examine this point later on in this section when we come to assess the data situation in Tasmania in relation to RPFM. But before doing this, we want to present the structure of our prototype RPFM. The Massachusetts model has been chosen as our prototype RPFM, and the model will be presented in full in the section to follow.

14. Recall that in footnote 12 above, we have mentioned the need for income data to implement a REBM.

The Massachusetts Model*Behavioural equations*

- | | | |
|-----|---|------------------------------|
| (1) | $X_t = \alpha_1 + \alpha_2 \text{GNP}$ | Export Function |
| (2) | $S_t = \alpha_3 + \alpha_4 (V_1)_t$ | Local Consumption |
| (3) | $(\log K_t - \log K_{t-1})_m = \alpha_5$
$+ \alpha_6 \log X_t^* + \alpha_7 \log K_{t-1}$ | Manufacturing Investment |
| (4) | $(\log K_t)_{nm} = \alpha_8 + \alpha_9 \log S_t^*$ | Non-manufacturing Investment |
| (5) | $V_2 = \alpha_{10} K^{\alpha_{11}} L^{(1-\alpha_{11})} (1 + \alpha_{12})^t$ | Production Function |
| (6) | $(N_e)_t = \alpha_{13} (P_e)_t$ | Expected Labour Supply |
| (7) | $M_t = \alpha_{14} + \alpha_{15} (N_e - L)_{t-1}$ | Migration |
| (8) | $W_t = \alpha_{16} (1 + \alpha_{17})^t$ | Wage Bargain |

Definitions and Identities

- | | |
|------|--|
| (9) | $P_e = (P_0)_{t-1} + (B - D)(P_0)_{t-1}$ |
| (10) | $(N_0)_t = a(P_e)_t + aM_t$ |
| (11) | $(V_2)_t / (V_1)_t = b$ |
| (12) | $(V_1)_t = S_t + X_t$ |
| (13) | $U_t = (N_0)_t - L_t$ |
| (14) | $K_t = (K_t)_m + (K_t)_{nm}$ |

* Asterisk indicates computed values.

Regional Dependent Variables

- (1) X = Export Income
- (2) S = Local Service Income
- (3) V_1 = Total Received Income
- (4) V_2 = Total Produced Income
- (5) K_m = Manufacturing Capital Stock
- (6) K_{nm} = Non-manufacturing Capital Stock
- (7) L = Employment
- (8) N_e = Expected Labour Supply (natural increase)
- (9) M = Migration
- (10) W = Annual Wage per Employee
- (11) P_e = Expected Population (natural increase)
- (12) N_0 = Labour Supply (actual)
- (13) U = Unemployment
- (14) K = Total Capital Stock

Regional Independent Variables

- (15) $(B-D)$ = Birth Rate *minus* Death Rate
- (16) P_0 = Population

National Variable

- (17) GNP = Gross National Product

Recall that the theoretical relationships of the Massachusetts model have been considered in some detail in Chapter Three above. Therefore, we will make no further comment on the relationships of the model, and move on to a discussion of its data requirements and the feasibility of obtaining the statistics required to construct a similar RPFM for Tasmania. If our model were to take the same form as the Massachusetts model presented above, then the data requirements for the Tasmanian model would consist of series for the seventeen variables listed on page 106 above. Examination of the Tasmanian data base shows that published information is available only for the following ten of these variables:

<u>Variable</u>	<u>Source</u>
GNP	1 (see below for key)
P_0	2
(B - D)	2
U	3
P_e	computed from P_0 & (B - D)
M	2 & 4
N_e	computed from P_e
N_0	computed from P_e & M
L	3
K_m	5

- Source: 1. *Australian National Accounts* (CBCS, Canberra)
 2. *Demography* (CBCS, Hobart)
 3. *Employment and Unemployment* (CBCS, Canberra)
 4. *Tasmanian Year Book*
 5. *Secondary Industries and Building* (CBCS, Hobart).

For the remaining seven variables, no published information is obtainable. The seven variables for which no published data is available are listed below:

<u>Symbol</u>	<u>Variable</u>
X	Export Income (i.e. income originating in the export sector)
S	Local Service Income
V_1	Total Received Income
V_2	Total Produced Income
K_{nm}	Non-manufacturing Capital Stock
W	Annual Wage per Employee, defined as the total annula wage bill divided by total employment
K	Total Capital Stock

We shall be exploring the possibility of constructing a series for one or both of V_1 and V_2 in Chapter Five. However, even if we were able to do this we shall still be left with a fairly large data gap. The builders of the Massachusetts model were faced with a similar gap (they had no published information on the first five of the seven variables listed above) and it may be that we could adopt the methods which they used to plug their gap in which case the construction of a Tasmanian RPFM would still be feasible. It seems clear, however, that this would require an extensive effort and that it would be far beyond the scope of the present study. Our final judgement, therefore, is that, having regard to data availability, the construction of a Tasmanian RPFM is not a feasible proposition at the present time.

4.5 Regional Social Accounting Model

The fourth and last type of REM which we have included in our feasibility study is the Regional Social Accounting Model RSAM . This type of REM is demand-oriented and has been used in the analysis of national final demand and its many components. A prototype RSAM (so-called) has been proposed by L. R. Klein and we will take this Klein model as our prototype for the RSAM class. The Klein model is presented in full below.

$$C_i = C_i(Y_i/p_c) \quad \text{Regional Consumption Function} \quad (1)$$

$$I_i = I_i(X_i, r, K_{i-1}) \quad \text{Regional Investment Function} \quad (2)$$

$$G_i^{SL} = G_i^{SL}(T_i^{SL}, N_i, r) \quad \text{Regional Government Expenditure} \quad (3)$$

$$E_i = E_i(X, p/p_i^m) \quad \text{Regional Export Function} \quad (4)$$

$$I_{m_i} = I_{m_i}(X_i, p_i/p_i^m) \quad \text{Regional Import Function} \quad (5)$$

$$p_c C_i + g I_i + G_i^{SL} + G_i^F + p_{e_i} E_i - p_i^m I_{m_i} = p_i X_i \quad \text{Gross Regional Product} \quad (6)$$

$$T_{p_i}^{SL} = T_{p_i}^{SL}(w_i L_i, \pi_i) \quad \text{Direct Regional Taxation} \quad (7)$$

$$T_{x_i}^{SL} = T_{x_i}^{SL}(p_i X_i) \quad \text{Indirect Regional Taxation} \quad (8)$$

$$T_i^F = T_i^F(w_i L_i, \pi_i) \quad \text{Federal Taxation} \quad (9)$$

$$T_{R_i} = T_{R_i}(U_i, N_i) \quad \text{Regional Transfer Payments} \quad (10)$$

$$D_i = D_i(K_{i-1}) \quad \text{Regional Capital Consumption} \quad (11)$$

$$Y_i = p_i X_i - T_{p_i}^{SL} - T_{x_i}^{SL} - T_i^F + T_{R_i} - g D_i \quad \text{Regional Disposable Income} \quad (12)$$

$$X_i = X_i(L_i, K_i) \quad \text{Regional Production Function} \quad (13)$$

$$P_i = P_i(p, w_i, P_i^m) \quad \text{Regional Price Level} \quad (14)$$

$$P_{e_i} = P_{e_i}(p, w_i, P_i^m) \quad \text{Regional Export Price Level} \quad (15)$$

$$w_i = w_i(U, U_i, P_c) \quad \text{Regional Wage Rate} \quad (16)$$

$$K_i = K_{i-1} + I_i - D_i \quad \text{Regional Capital Stock} \quad (17)$$

$$T_i^{SL} = T_{P_i}^{SL} + T_{X_i}^{SL} \quad \text{Total Regional Taxation} \quad (18)$$

$$\pi_i = P_i X_i - g D_i - w_i L_i - T_{X_i}^{SL} \quad \text{Regional Non-Wage Income} \quad (19)$$

$$\text{and } U_i = \beta_i N_i - L_i \quad \text{Regional Unemployment} \quad (20)$$

Regional endogenous variables (i^{th} region):

- (1) C_i = Consumer Expenditures
- (2) Y_i = Disposable Personal Income
- (3) I_i = Capital Formation (fixed non-residential, residential, inventory change)
- (4) X_i = Gross Regional Product
- (5) G_i^{SL} = State and Local Expenditures on Goods and Services
- (6) T_i^{SL} = State and Local Receipt
- (7) E_i = Exports of Goods and Services
- (8) P_{e_i} = Price Index of Exports
- (9) I_i^m = Imports of Goods and Services
- (10) P_i = GRP deflator
- (11) $T_{P_i}^{SL}$ = State and Local Direct Taxes
- (12) w_i = Wage Rate

- (13) L_1 = Employment
- (14) π_1 = Non-wage Factor Income
- (15) $T_{x_1}^{SL}$ = State and Local Indirect Taxes
- (16) T_1^F = Taxes paid to Federal Government
- (17) T_{R_1} = Transfer Payments
- (18) U_1 = Unemployment
- (19) D_1 = Capital Consumption
- (20) K_1 = Capital Stock

Regional exogenous variables:

- (21) N_1 = Population
- (22) G_1^F = Federal Regional Expenditures on Goods and Services
- (23) β_1 = Regional Participation Rate for Labour Force

National variables:

- (24) p_c = Index of Consumer Prices
- (25) r = Interest Rate
- (26) p = GNP deflator
- (27) p_1^m = Import Price Index
- (28) X = GNP
- (29) U = National Unemployment

Since our main interest in this chapter is the data problem associated with REM, the theory behind the relationships in the Klein model will not be commented on. Rather, we will concentrate on the discussion of the data requirements for the model. To implement a RSAM such as the Klein model, it is necessary to have time series

data for all variables included in the above model. The majority of these variables are components of a system of regional income and product accounts. Unfortunately, such a set of accounts does not exist for the State of Tasmania and, if we were to build a RSAM for the Tasmanian economy, estimates of the components of these accounts would have to be made. But before we look at the feasibility of building up a system of Tasmanian income and product accounts, it will be helpful to consider two examples of RSAM which have been built either on an incomplete set of regional social accounts, or on a system of accounts which made extensive use of secondary data.¹⁵ The Ohio model is an example of a RSAM build on an incomplete set of regional income and product accounts. The deficiencies of the set of accounts used in the Ohio model were mainly on the expenditures side. No foreign sector was included in the model because of an absence of foreign trade data. Because no statistical series for personal consumption expenditure existed for the State of Ohio, the builders of this model used instead the proxy variable, retail sales. Investment functions were estimated for the manufacturing sector only. Hence, for all these reasons, GSP could not be estimated from the expenditure side. For similar reasons, GSP could not be estimated from the income side. Of the many income components, only personal income was explained in the

15. The term "primary data" is often used to denote data which has been obtained directly from regional data-collecting agencies. Secondary data are those which have not been collected from such agencies but are often estimated by allocating a share of the components of the national income and product accounts to the region.

model. The model was most extensive in its treatment of the production sector. GSP was estimated from the sum of its components, i.e. gross product originating in the various production sectors. In spite of its many deficiencies, the Ohio model was used successfully for such policy purposes as determining the effect of the national economy on the State economy.

The Illinois model is an example of RSAM built on a system of regional social accounts which made extensive use of secondary data. Due to the difficulties involved in estimating the components of the accounts, the system was derived by allocating a share of the components of the national income and product accounts to Illinois. In this model, GSP was defined as "Total output at market prices produced by resources owned by residents of Illinois."¹⁶ Thus the Illinois model employed a Gross National Product concept (instead of a Gross Domestic Product concept) of GSP. Hence, GSP was, by definition, equal to total "received" income and accordingly the model estimated GSP from the income side of the accounting framework. The components of Gross State Income and Gross State Product were as given in Table 4.2.

Items (1) to (4) of Table 4.2 were major components of the Personal Income series and were available from published sources. The remaining components of income were estimated by "allocating the national total of the component to Illinois on the basis of components of Personal Income and certain tax variables from the Illinois Department of Revenue."¹⁷ It was pointed out that different allocators

16. See R. J. Green, *op. cit.*, p. 22.

17. R. J. Green, *ibid.*, p. 17.

Table 4.2

<u>Income</u>	<u>Product</u>
(1) Compensation of Employees	(10) Consumption Expenditure
(2) Net Interest	(11) Investment Expenditure
(3) Rental Payments	(12) State and Local Government Expenditure
(4) Proprietor Income	(13) Net Exports (unallocated component)
(5) Corporate Profits	
(6) Indirect Business Taxes	
(7) Personal Contribution to Social Insurances	
(8) Capital Consumption Allowances	
(9) Less Subsidies less Current Surplus of Government Enterprises	
= Gross State Income	= Gross State Product

were used for each component of income. The methods used to estimate the expenditure items of Table 4.2 are explained in the following passage. The consumption variable was derived by first estimating Personal Saving and then subtracting Personal Saving from Disposable Personal Income. Personal Saving was estimated by allocating the components of the Securities Exchange Commission estimates to Illinois. The allocators used are discussed in detail in the source notes to Appendix Table A.2. Disposable Personal Income was published by states. The Investment and Government Product variables were also estimated using allocators. The unallocated variable was then calculated as a residual (Net Exports

in Table 4.2). It was noted that the treatment of Net Exports in the Illinois Account was significantly different from that used in the national account because "there is no realistic way to estimate time series for imports and exports at the State level it is necessary to estimate Net Exports as a residual."¹⁸

From the experience of the Ohio model, we have learnt that a RSAM can be built even on an incomplete set of accounts. Although there will be deficiencies because of the missing relationships, it is still possible to put together enough relationships to make the model a useful policymaking tool. From the experience of the Illinois model we have learnt that a regional social accounting system can be built up by using secondary data. But, of course, such an account system will not be as reliable as one using primary data.

Let us now return to the case of a Tasmanian RSAM. Assuming that we wished to construct an RSAM for Tasmania similar to the Klein model, the data situation would be as summarized in Table 4.3. From Table 4.3 it is apparent that the data gaps are so extensive that the construction of a RSAM of the Klein type for Tasmania would require data-collecting efforts far beyond the resources available to this study. For this reason, we regard such an undertaking as infeasible at this stage.

4.6 Conclusion

We will now sum up our feasibility study. In Sections 4.2 through 4.5, we have considered the feasibility of constructing each

18. R. J. Green, *ibid.*, p.26

Table 4.3
Tasmanian data source for implementing the Klein model

<u>Symbol</u>	<u>Variable</u>	<u>Source</u>
C	Consumption Expenditure	1 (see below for key)
Y	Disposable Income	1
I	Investment Expenditure	2 (for manufacturing sector only)
X	Gross Regional Product	not available
G ^{SL}	State Expenditures	1
T ^{SL}	State Receipts	1
E	Exports	3
P _e	Export Price Index	not available
I ^m	Imports	3
P _i	GRP deflator	not available
T _p ^{SL}	State Direct Taxes	1
w	Wage Rate	4
L	Employment	4
π	Nonwage Factor Income	not available
T _x ^{SL}	State Indirect Taxes	not relevant
T ^F	Taxes paid to Federal Government	1
T _R	Transfer Payments	1
U	Unemployment	4
D	Capital Consumption	not available
K	Capital Stock	not available
N	Population	5
G ^F	Federal Regional Expenditures	1
β	Participation rate	5
P _c	National Index of Consumer Prices	7
r	Interest Rate	7
p	GNP deflator	
P ^m	Import Price Index	7
X	GNP	6
U	National Unemployment	4

Source:

1. *Finance*, (CBCS, Hobart)
2. *Secondary Industries and Building*, (CBCS, Hobart)
3. *Trade and Shipping*, (CBCS, Hobart)
4. *Labour Report*, (CBCS, Canberra)
5. *Demography*, (CBCS, Hobart)
6. *Australian National Accounts*, (CBCS, Canberra)
7. *Quarterly Summary of Australian Statistics*, (CBCS, Canberra).

of four types of REM for the Tasmanian economy. By looking at a prototype model for each type of REM, we gained an idea as to the data requirements for a similar Tasmanian model. We then compared these data requirements with the available Tasmanian statistics with a view to assessing the extent of the data problem which was likely to be associated with the construction of each type of REM for Tasmania. Looking at some of the existing REM, we have also learned something about ways of coping with the problem of data unavailability. The conclusions which we have reached as a result of this procedure are that the data problem for the first two types of REM, i.e. the Regional Empirical Model and the REEM, are not likely to be insuperable. On the other hand a serious data problem is likely to face us if we attempt to build a RPFM and a RSAM for Tasmania. Accordingly, we judge the construction of the first two types to be a feasible undertaking but not the construction of models of the third and fourth types. This is most unfortunate because, as mentioned in Chapter One above (Section 1.2), both REEM and REMM which we constructed for Tasmania do not make use of the available trading statistics. While a RSAM would be the best type of REM to incorporate these trading statistics, the construction of a RSAM for Tasmania is not feasible at this stage. The construction of a Regional Empirical Model for Tasmania will be proceeded with in Chapter Six and the construction of a REEM in Chapter Seven.

CHAPTER FIVEESTIMATION OF GROSS STATE PRODUCT FOR TASMANIA5.1 Introduction

In Chapter Four above, we have on several occasions drawn attention to the important role played by the variable, gross state product, in regional econometric model-building. Apart from this, GSP is an important indicator in itself and estimates of GSP are required to implement various kinds of analyses dealing with regional problems. Estimates of GSP would provide a measure of the relative levels of income and output in the different regions. Without it very little is known of their comparative efficiency or standard of living. If such estimates were produced regularly they could also provide useful information on the economic growth of regions. Furthermore, if the estimates were built up industry by industry they would provide an analysis of the economic structure of regions; and when set beside statistics for employment, they would give comparative figures of output per head in different industries. For all these reasons, we have decided to devote this chapter exclusively to the task of estimating a GSP series for Tasmania. This will be used in the construction of a REMM for Tasmania in Chapter Six and will also be used in Chapter Eight.

However, before we start on the actual estimation procedure, we must make clear the nature of the regional aggregate to be measured. This we will do in Section 5.2 where we describe briefly the underlying concept of GSP to be implemented statistically, and explain our preference for the state equivalent of the concept of gross national product at factor cost. In Section 5.3, we will list the three common approaches to the problem of estimating GNP, and consider the feasibility of employing each approach in the estimation of GSP for Tasmania.

Then in the Sections 5.4 and 5.5 we will describe the procedures which we actually followed. Two approaches were used. The first (the "income approach") will be described in Section 5.4. In this approach, our estimates of GSP are based on income data derived from the tax statistics. The second (the "production approach") will be explained in Section 5.5. In this approach, we resort to production census data (for primary and secondary industries) and income data (for tertiary industries).

In Section 5.6, we will describe the procedure used to break the GSP aggregate down into its principal income components. Since most income components of GSP are covered in the series for personal income, by type, it was necessary only to separate entrepreneurial income into its two components of company income and gross operating surplus of public enterprise in order to effect the desired breakdown of GSP.

Whereas the breakdown of the GSP aggregate into its principal income components provides a basis for the analysis of factor incomes, the study of regional economic growth requires

estimates of GSP at both current and constant prices. Hence in Section 5.7 we will describe the "deflation method" used to eliminate the effects of price changes from the current-price estimates.

It must be stressed that our main interest in this chapter is in the GSP aggregate. Hence, the work of Section 5.6 must be regarded as subsidiary. Also, we must stress our preference for a simple rather than a complicated procedure of estimation. For, as we will see in Section 5.4 and Section 5.5, nearly 75% of the data used in the estimation process are obtained directly from publications of the *Commonwealth Bureau of Census and Statistics (CBCS)*. Hence we can reasonably hope that even if we make big errors in estimating the remaining 25%, the estimates of the GSP aggregate will still be reasonably close to the mark. By the same token, we will prefer to rely on readily-available information sources rather than undertaking ourselves the tedious task of searching for missing data. For such data collection is well beyond the scope of our study.

5.2 Concepts of Gross State Product

In this section, we will explain the conceptual framework used for our estimation of GSP. As a preliminary definition, we may say that GSP is a measure of the value of the economic production of the State in the sense of aggregate value added. Two main points arise from this definition. The first relates to the coverage to be adopted. For the economic production referred to can be either that for which the residents of the State are responsible or that which takes place within the geographic area of the State. Secondly, we

must consider whether the economic production referred to is measured in terms of market prices or in terms of the factor payments which it generates. Different ways of dealing with these points give rise to different concepts of GSP.

Taking the first point, the first alternative gives rise to the "national" concept of GSP in which case GSP is regarded as measuring the income ultimately received within the State and hence is sometimes called "total received income" of the State. The second alternative leads to the "domestic" concept of GSP in which GSP is regarded as measuring the income originating within the State and hence is sometimes called "total produced income" of the State. From the point of view of data availability and from the standpoint of measurement and analysis of production and productivity, the "domestic" concept is often preferred to the "national" concept. From the point of data availability, the lack of information on the flow of property income either into or out of a region makes it difficult to implement the "national" concept of GSP. Moreover, since the domestic concept covers all economic activity within a geographical area, regardless of ownership considerations, it is preferable to the "national" concept when a measure of performance of the state economy is required. For these reasons as well as for the reason that we shall later require to make a regional allocation of the Australian GNP, we have decided to adopt the domestic concept of GSP as a framework for our estimation work.

Turning now to the second point, the first alternative leads to a "market price" concept of GSP while the second alternative leads to a "factor cost" concept. The two concepts differ in that market

price concept includes net indirect business taxes whereas these are excluded in the factor cost concept. At the national level it has been found difficult, both conceptually and in terms of data requirements, to allocate total net indirect business taxes to industries.¹ It has been argued that it is difficult to decide whether indirect taxes originate with purchasing industries or selling industries, and that as a result, the meaning of the market price concept of gross domestic product by industry of origin, is somewhat obscure. Also, unevenly applied indirect taxes and excluded subsidies will produce a distorting effect on the resulting estimates of industry gross product. Hence, it is concluded that the market price concept, while useful for demand analysis, is "irrelevant when dealing with the supply side of economic production".²

Since our estimates of GSP will be based mainly on the allocation to the State of the relevant national totals, it is to be expected that similar difficulties would arise if the "market price" concept of production were to be used. For these reasons we have opted for gross domestic product at factor costs as our GSP concept in this study.

1. See G. J. Garston and D. A. Worton [20].

2. Garston and Worton, *Ibid.*, p. 423.

5.3 Alternative Approaches to Estimation of Gross State Product

As mentioned in the last section, owing to the paucity of regional data, regional income and product estimates are frequently obtained through the allocation of national totals to the regions. When this is done, the regional totals should be reconciled with national control totals in order to emphasize the analytical and statistical interdependence of regional and national estimates. Consequently, the framework within which regional income and product estimates are made is predetermined to some extent by the national accounting system. Working within such a framework, it was concluded in the last section that the requirements of regional disaggregation of the national totals dictated a "domestic at factor costs" concept of economic production. In the present section, we will describe three alternative approaches to the estimation of this concept of gross state product. Then, we will assess the feasibility of implementing each approach in the Tasmanian context.

Like its national counterpart, GSP can be interpreted in three different ways: as the sum of expenditures, as the sum of income payments to the factors of production, and as the sum of each industry's gross product. Each interpretation offers an approach for estimation. These three interpretations of GSP are depicted in Table 5.1. In the first approach, GSP can be derived as the sum of expenditures for consumption, investment (including changes in business inventories), government purchases, and net exports of goods and services. This may be labelled the expenditure-approach which is familiar in estimating GNP in the conventional income and product

Table 5.1

Gross State Product - Alternative Interpretations

A. Gross State Expenditure	B. Gross State Income	C. Gross State Product
Personal Consumption Expenditure Gross Private Business Investment: Expenditure on Building and Construction Expenditure on Plant and Equipment Inventory Change Net Exports of Goods and Services Government Purchases of Goods and services: Federal State and Local	Labour Compensation: Wages, Salaries and Supplements Income of Unincorporated Enterprises: Farm Non-Farm Dwelling Rent Company Income and Inventory Valuation Adjustments Gross Operating Surpluses of Public Enterprises = Total Factor Income Net Indirect Business Taxes Depreciation Allowances	Government Farm Non-Farm: Mining and Quarrying Manufacturing Electricity, Gas, and Water Supply Building and Construction Transport and Communication Commerce Community and Business Services Finance and Property Ownership of Dwellings All Other Industries
Total Gross Expenditure	Total Gross Income	Total Gross Product

accounts.³ GSP can also be derived as the sum of income payments to the factors of production (labour compensation, profits, income of unincorporated enterprises, rent, interest) plus nonfactor charges (indirect business taxes, depreciation, etc.). This alternative, called the income-approach, to the estimation of GSP is the most common one adopted in most regional studies.⁴ The reason is, of course, that, unlike the expenditure data or the census production data which can be obtained only with difficulty, reliable regional income data are usually available. The third approach to the estimation of GSP is the production-approach. In this approach, GSP is derived as the sum of each industry's contribution to the State's total output of goods and services. Each industry's gross product (or value added) represents the value of production in each industry, less its purchases of materials and intermediate services. Conceptually, the three measures (total gross expenditure, total gross income, and total gross product) are identical. The sum of gross product by industry is equal to gross expenditure since the value of "final" products is equal to the value added at each stage of production. Value added in each industry, on the other hand, is equal to the factor costs (payments) plus other charges against product in each industry, which sum to equal aggregate gross income originating in the geographical area of the State. Therefore, total gross product equals total gross expenditure which, in turn, equals total gross income. But in practice, owing to imperfections

3. See, for example, *Australian National Accounts (ANA)*, published by the CBCS.

4. The income-approach is also the one adopted to estimate GNP in Australia. See *ANA*, 1970-71, p. 2.

inherent either in the available data or in the estimation methods employed, or because the available statistics are different in concept from those required, or possibly for many other reasons, statistical discrepancies do occur between different estimates of GSP when all the three estimation methods are used.

In most national income estimation, all the three alternative approaches to the estimation of GNP are used. At the regional level, however, one or more of the three approaches are frequently infeasible because both the availability and the quality of regional data are, in general, less satisfactory than is the case with the corresponding national data. Indeed, the paucity of regional data usually forces the investigator to make a choice from the alternative approaches to estimation. The familiar expenditure-approach is not generally feasible since regional data for a number of final product segments, particularly the balance of payments items are generally required. As recalled from our survey on regional econometric models, most regional studies, except for the so-called "island economies" such as Hawaii and Puerto Rico in the U.S.A., have to employ approaches other than the expenditure-approach to estimate GSP.⁵ Since Tasmania is also an island-economy, the problem of getting the balance of payments items would not be as critical as that facing other

5. See Chapter Three. The lack of enthusiasm for the expenditure-approach at the regional level could also be due to the fact that regional studies are less prone to the analysis of final demand (product) than the national studies, for economic stabilization is not regarded as the responsibility of regional governments.

mainland economies such as Western Australia.⁶ But data deficiency is still sufficiently serious to prohibit the estimation of GSP by the expenditure- approach at this stage. Among other things, data on investment expenditures in the private sector are available only for primary industries and manufacturing industries, but not for tertiary industries. Another difficulty arises from the lack of estimates of the balance of payments on "services", although information on "commodity" exports and imports is available. Also, information on federal government expenditures in Tasmania is not readily available and their correct assessment is difficult.

The income-approach gives an estimate of GSP which is based on income data. These income data are derived from taxation statistics and are on an enterprise (instead of on an establishment) basis. The State's personal income series as published by *Australian National Accounts* is one great source of income data from which estimates of GSP can be calculated by the income-approach. As mentioned earlier,⁷ estimation of GSP by the income-approach requires separate estimates of the income components - (1) wages, salaries and supplements, (2) income of unincorporated enterprises of both the farm and the non-farm sectors, (3) dwelling rent, (4) company income and inventory valuation adjustments, (5) gross operating surpluses of public enterprises, and (6) the non-factor costs (net indirect business taxes and depreciation allowances). The first three

6. Recall that in Chapter One, Section 1.2, we have discussed this point.

7. See Table 5.1 above setting out the components of Gross State Income.

income components are included in the State's personal income series and can be transferred directly to the estimate of GSP. Admittedly, the personal income components are on an "incomes-received" basis whereas the GSP components are on an "accrued income" or "income-earned" basis. However, the two estimates will differ significantly only if a great deal of inter-state commuting takes place which is not the case as regards Tasmania.

Turn now to the remaining two income components and the non-factor cost element. Estimates of company income can be obtained by direct allocation to the State of a share of the Australian total. The gross operating surpluses of public enterprises can be handled similarly. Because we have adopted a "factor cost" (instead of a "market price") concept of GSP, we need not estimate net indirect business taxes. Also, because depreciation allowances are already included in the gross operating surpluses of companies and public enterprises in *Australian National Accounts (ANA)*,⁸ we can forget about depreciation allowances in our estimation of GSP. Hence, by blowing up the income components of the State's personal income series by the Australian ratios, we can get estimates of GSP for Tasmania by the income-approach. The details of this procedure are described in Section 5.4.

Lastly, in this section, we will consider the feasibility of implementing the production-approach for Tasmania. The production-approach requires, on an industry-by-industry basis, information on both values of production and costs of intermediate products. In the

8. See Tables 25 and 26 in *ANA*, 1970-71.

context of Tasmania, this information is available only for the primary industries and for manufacturing industries. For the calculation of tertiary industry products, one has to resort to the use of incomes-received data. Since tertiary industry product represents about half of total GSP,⁹ it appears that the production-approach is not as feasible as the income-approach in the Tasmanian case. An attempt to estimate GSP by the production-approach is nevertheless undertaken in this study in Section 5.5 below.

5.4 Estimation of Gross State Product using the Income-Approach

In this section, we will describe the income-approach to the estimation of GSP for Tasmania. Using this approach, estimates of GSP are obtained by summing income flows in Tasmania. In this context, GSP may be regarded as comprising income from employment (including wages, salaries and supplements to wages and salaries), income of unincorporated enterprises (both farm and non-farm), income from dwelling rent, company income (including allowances for depreciation), and the gross surpluses of public authority business undertakings. Since a large proportion of data, like employment income and income of unincorporated enterprises, are common to both gross national product and personal income, the same estimates as are employed in personal income by states can be used to derive gross state product.¹⁰

-
9. In 1964-65, tertiary gross product for Tasmania was estimated at 271.0 million dollars while total GSP was 491.5 million dollars. See computations in Section 5.5, p. 141 below.
 10. The proportion of income from current production (i.e. wages, salaries and supplements, and income of unincorporated enterprises) to GNP at factor cost ranges from 82% in 1953-54 to 74% in 1969-70. See Appendix Table A5.1.

The breakdown of the State's personal income series into its principal components as published in ANA has facilitated our estimation of GSP using the income-approach. This can be explained by referring to Table 5.2 which has listed, side by side, the various components of personal income and GSP. It can be seen from Table 5.2 that the first three components (wages, salaries and supplements, income of unincorporated enterprises, and dwelling rent) are common to both personal income and GSP. Thus, these three components of income can be transferred to the estimates of GSP without making any adjustments.¹¹ It remains only to estimate company

Table 5.2

Components of GSP and Personal Income

(1) Wages, Salaries and Supplements	(1) Wages, Salaries and Supplements
(2) Income of Unincorporated Enterprises	(2) Income of Unincorporated Enterprises
(3) Dwelling Rent	(3) Dwelling Rent
(4) Company Income and Inventory Valuation Adjustments	(4) Cash Benefits from General Government
(5) Gross Operating Surpluses of Public Enterprises	(5) All Other Income
Gross State Product	Total Personal Income

income and the gross operating surpluses of public enterprises. These two items may be considered as the return to entrepreneurship in

11. Admittedly, this statement is not strictly correct because personal income are cash income received whereas GSP are accrued income to factors. But as said earlier on p. 133, the difference between these two income estimates would be negligible in the Tasmanian context due to absence of inter-state commuting.

Tasmania, and we will call their sum total "entrepreneurial income". Essentially, the Tasmanian entrepreneurial income is estimated by allocating the state share of the corresponding national total. The choice of allocator is quite arbitrary, however, depending on availability of state data. In this exercise, we have found it convenient to allocate the state share of the Australian total of entrepreneurial income (defined as the excess of GNP at factor cost over labour income from current production, i.e. the sum of wages salaries, and supplements, and income of unincorporated enterprises) on the basis of labour income from current production. In Table 5.3 we work through this exercise for the year 1964-65 in order to illustrate the method. Estimates of GSP for Tasmania for other years are given in Table A5.1 in the Appendix. This table also gives the proportion of labour income from current production to GSP. It will be seen that labour income from current production constitutes a very high proportion of GSP.¹² Since the figures for labour income from current production are obtained directly from publications of the *Commonwealth Bureau of Census and Statistics (CBCS)*, our estimates of GSP by the income-approach should be reasonably accurate.

An alternative approach to the estimation of GSP for Tasmania is also attempted in this study. This alternative is the production-approach. Unlike the income-approach just described which is based on income data derived from payroll tax and income tax statistics, the production-approach is based primarily on production-census data.

12. The proportion of labour income from current production to GSP ranges from 82% in 1953-54 to 74% in 1969-70.

Table 5.3Estimation of the Tasmanian GSP using the Income-Approach, 1964-65*Australian figures used (\$m.):*

GNP at factor cost =		17,784
less Labour Income from Current Production:-		
Wages, Salaries, and Supplements	9,932	
Income of Unincorporated Enterprises	3,531	
	<hr/>	<hr/>
equals Entrepreneurial Income		4,321

Tasmanian figures used (\$m.):

Wages, Salaries and Supplements	277
add Income of Unincorporated Enterprises	78
	<hr/>
equals Labour Income from Current Production	355

Thus, Tasmanian Entrepreneurial Income in 1964-65 is given by:

$$\frac{\text{Tasmanian Labour Income from Current Production}}{\text{Australian Labour Income from Current Production}} \times \text{Australian Entrepreneurial Income}$$

$$= \frac{355}{13,463} \times 4,321 = \$114\text{m.}$$

It follows that:

Tasmanian GSP at factor cost in 1964-65 is given by :

$$\begin{aligned} \text{Tasmanian Labour Income from Current Production} &+ \text{Tasmanian} \\ \text{Entrepreneurial Income} &= 355 + 114 \\ &= \$469\text{m.} \end{aligned}$$

However, the paucity of this type of data in the tertiary industries will usually force the investigator to use a combination of both types of data. The procedures which we have used for estimating GSP for Tasmania by the production-approach are described in the following section. The estimates thus derived can serve as a consistency check on the income-based estimates of GSP described above.

5.5 Estimation of Gross State Product using the Production-Approach

In this section, we will describe the procedures used in estimating GSP for Tasmania by the production-approach. According to this approach, estimates of GSP are obtained for Tasmania by summing product values, i.e. value added in terms of factor cost, industry by industry. The industry classification scheme used is the same as that in *Australian National Accounts (ANA)*.

Basically, the method involves valuing the output of goods and services for each industry and then deducting the cost of all materials (and services) used in the process of production to arrive at value added in terms of factor cost. However, the process of estimating the value added for each industry is very complicated and is not undertaken in this study. Rather, we will try to obtain the approximate value added figures using published information of the *Commonwealth Bureau of Census and Statistics*. We have found that for both the primary and secondary industries, the official "net recorded value of production" figures can be used to approximate the value added figure for the industry. Value added is a less gross concept than the net recorded value of production, and "... estimates of

miscellaneous expenses such as maintenance of buildings, motor vehicle operating expenses, insurance, advertising, etc., [should] be deducted from the recorded value of production in order to obtain estimates of gross product [value added]."¹³ Again, the estimation of these "miscellaneous expenses" which are necessary for reconciling the two concepts of production is not undertaken in this study. Rather, we will try to estimate value added (gross product) for these industries (primary and secondary) from the net recorded value of production on the basis of the Australian proportion of gross product at factor cost to net recorded value of production. An illustration of this method is given in Table 5.4.

Now we will turn to the estimation of gross product originating in the tertiary industries which include electricity, gas, and water supply; building and construction; transport and communication; commerce; public administration and defence community and business services; finance and property; and all other industries. For these tertiary industries, we cannot apply the above method of estimating gross product because no production-census data such as "net recorded value of production" are available. For these industries, therefore, it becomes necessary to estimate gross product as the incomes received, thus resorting to the use of income data. Our procedure for estimating gross product in the Tasmanian tertiary industries is to allocate to the State a share of the Australian total,

13. See *Supplements to ANA*, "Estimates of Gross Product by Industry at Current and Constant Prices, 1959-60 to 1965-66", CBCS, Ref. No. 7.7, June 1969, p. 6.

Table 5.4

Estimation of Gross Product (Value Added) from Net Recorded Value of
Production, 1964-65

Australian figures used (\$m.):

Primary Industries (excluding Mining and Quarrying):

Gross Product originating	2184
Net Value of Production	2744

Hence, GROSS PRODUCT/Net Value of Production = $\frac{2184}{2744}$ = 0.795

Mining and Quarrying

Gross Product originating	309
Net Value of Production	400

Hence, GROSS PRODUCT/Net Value of Production = $\frac{309}{400}$ = 0.773

Manufacturing

Gross Product originating	5089
Net Value of Production	5897

Hence, GROSS PRODUCT/Net Value of Production = $\frac{5089}{5897}$ = 0.862

Tasmanian figures used (\$m.):

Primary Industries (excluding Mining and Quarrying):

Net Value of Production	= 85
-------------------------	------

Australian proportion of (GROSS PRODUCT/Net Value of Production) applied	= 0.795
---	---------

Hence, Tasmanian Gross Product originating = 85×0.795 = 62.5 (\$m.)

Mining and Quarrying

Net Value of Production	= 18.2
Australian proportion applied	= 0.773

Hence, Tasmanian Gross Product originating = 18.2×0.773 = 14.0 (\$m.)

Manufacturing

Net Value of Production	= 167
Australian proportion applied	= 0.862

Hence, Tasmanian Gross Product originating = 167×0.862 = 144 (\$m.)

Summary of Industry Gross Products for 1964-65:

GROSS PRODUCT originating in Primary Industries (excluding Mining and Quarrying)	= <u>62.5</u> (\$m.)
---	----------------------

GROSS PRODUCT originating in Mining and Quarrying	= <u>14.0</u> (\$m.)
---	----------------------

GROSS PRODUCT originating in Manufacturing	= <u>144.0</u> (\$m.)
--	-----------------------

industry by industry, on the basis of labour income from current production, i.e. wages, salaries and supplements,¹⁴ and income of unincorporated enterprises. This procedure is illustrated in Table 5.5 for the year 1964-65.

Thus our estimate of GSP for 1964-65 using the production-approach is given by:

<i>Gross Products:-</i>	(\$m.)
Primary	62.5
Mining and Quarrying	14.0
Manufacturing	144.0
Tertiary	271.0
	<hr/>
GROSS STATE PRODUCT	= 491.5
	<hr/>

Recalling that our estimate of GSP for 1964-65 by the income-approach was 469 million dollars, we see that there is a discrepancy between the estimates given by the two approaches for 1964-65 of 22.5 million dollars. In view of the amount of extra work involved in the production-approach, and the fact that the industry distribution of labour income from current production is not available except for the year 1964-65 so that some other method of dealing with the tertiary industries would have to be used, the income-approach as described in Section 5.4 is preferred for the estimation of GSP in this study. On the other hand, the production-approach, described in this section, provides a convenient way of obtaining the industrial sub-division of GSP. Such a sub-division is necessary for the study of industrial

14. The industry distribution of this series for 1964-65 is obtained from unpublished information of the CBCS.

Table 5.5

Estimation of Tertiary Industry Gross Product, 1964-65

Industry	National Totals (\$m.)			State Totals (\$m.)	
	Labour Income from Current Production (a)	Gross Product Originating (b)	Ratio of (b)÷(a) = (c)	Labour Income from Current Production (d)	Gross Product Originating (e)=(c)×(d)
Electricity, Gas, and Water Supply	227	597	2.63	15.7	41.3
Building and Construction	1334	1436	1.07	18.5	19.8
Transport and Communication	1093	1442	1.32	32.5	42.8
Commerce	1902	2538	1.33	51.0	68.0
Public Administration and Defence	603	603	1.0	46.0	46.0
Community and Business Services	1403	1425	1.01	22.2	22.5
Finance and Property	486	588	1.21	13.3	16.1
All Other Industries	584	674	1.15	12.6	14.5
Total					271.0

structure of the region and for the analysis of production and productivity.¹⁵ But these matters are quite beyond the scope of this study and will not be pursued further.

5.6 Components of the Tasmanian Gross State Product

The two preceding sections aimed at providing a total for GSP. But often, stress is laid on the breakdown of GSP into its components. An obvious and important example is in the study of the distribution of factor incomes. In this kind of study, a breakdown of the aggregate into its principal components is essential.

As recalled in Section 5.4 above, the State's personal income, by type of income, as published in the tables of *Australian National Accounts* covers three out of five principal income components of GSP.¹⁶ The remaining two income components (company income and inventory valuation adjustment, and gross operating surpluses of public enterprises) are lumped together to give estimates of entrepreneurial income. In this section, we will try to break this total down into its two components so as to achieve a complete breakdown of the GSP aggregate into its five components. A recent publication of the *Commonwealth Bureau of Census and Statistics* has made this possible. Figures for gross operating surpluses of public enterprises in the State are published in *Public Authority Finance*.¹⁷

15. See, for example, G. McCrone [37].

16. See Section 5.4, p. 135.

17. *Public Authority Finance*, Bulletin No. 1, 1969-70, CBCS, Canberra, Table (80) - Tasmania.

This leaves only company income to be estimated.

Company income produced in the region is often the most difficult component to be estimated in the income-approach. Companies operating in a region may have branches or have their central office in some other regions. Since data for company income are based on company income tax statistics, any difference between the place of assessment of company income and the region to which the income may properly be said to accrue will play havoc with regional estimates. For the companies assessed in the region are not necessarily all the companies contributing to the gross regional product of the region concerned. A method of estimating company income for a region for the case of company income being assessed in the region, and also for the case when regional company income is assessed at the central office is put forward by A. Kerr.¹⁸ However, to follow this method of estimating regional company income, it is necessary to make an extensive search into the income tax statistics as well as undertaking the time-consuming task of compiling the statistics. For these reasons, Kerr's method of estimating company income will not be followed in our study.

As mentioned in Section 5.1, our main objective in this chapter is to obtain reasonably accurate estimates of GSP through the simplest possible procedure. We have also stipulated that we prefer to get our estimates of GSP through readily available sources rather than by undertaking a detailed and time-consuming data estimation process. Hence, we prefer to estimate company income produced in

18. See A. Kerr [33].

Table 5.6

Principal Components of the Tasmanian GSP, 1964-65 to 1968-69, (\$m.)

Income Components	1964-65	1965-66	1966-67	1967-68	1968-69
<i>Australian figures used:</i>					
(1) Wages, Salaries and Supplements	9932	10699	11674	12696	14046
(2) Company Income	2828	2861	3164	3588	4027
(3) Ratio of (item (2)/item (1))	.285	.268	.271	.283	.286
<i>Tasmanian figures used:</i>					
(4) Wages, Salaries, and Supplements	277	302	335	362	389
(5) Income of Unincorporated Enterprises:-					
Farm	39	31	36	21	33
Non-farm	39	41	44	46	48
(6) Dwelling Rent	10	10	12	11	11
(7) Gross Operating Surpluses of Public Enterprises	20	21	22	22	28
(8) Company Income = (3) × (4)	79	81	91	102	111
(9) GSP at factor cost (from Table A5.1 in the Appendix)	469	493	546	575	630
(10) (Company Income as Residuals) = (9) - [(4) + (5) + (6) + (7)]	(84)	(88)	(97)	(113)	(121)

Tasmania by allocating the state portion of the Australian total. A variety of allocators have been suggested in other regional studies concerning the allocation of the regional share of the national total. These include the ratio which wages and salaries and sales in a region have to the national totals,¹⁹ the ratio of regional dividends received to the national total,²⁰ factors which reflect the ownership of capital, excluding land and buildings,²¹ and so on. In our case, we cannot find an allocator more suitable than the ratio of wages, salaries and supplements, and this is the allocator which has been used. To clarify the procedure, the computations for the period 1964-65 to 1968-69 are shown in Table 5.6 together with an alternative computation in which Tasmanian company is treated as a residual.

5.7 Estimates of Gross State Product at Constant Prices

Recall that in Section 5.4 above, we have made estimates of gross state product for Tasmania by the income-approach. These estimates have been measured in terms of the actual prices at which transactions have taken place, i.e. at current prices. A time series of GSP so constructed will reflect both changes in prices and changes in quantity. However, when one wishes to analyse the behaviour of the economic system, it is desirable to separate the price change in the time series. This is especially true in our case when we

19. See H. J. Adler [64].

20. See the Illinois model in Chapter Three, Section 3.3.2c.

21. See A. D. Campbell, "Income" in A.K. Cairncross (ed.) [9].

want to assess Tasmania's economic growth or when we want to compare it with that of Australia. For such a purpose, the growth of the Tasmanian economy can be assessed properly only if GSP is expressed at constant prices; that is, when GSP is expressed in the prices of a fixed base year so that quantity changes can be isolated. Therefore, for analytical purposes and in order to derive a measure of "real" growth in the economy, the current-price estimates of GSP are deflated in order to obtain a measure of constant-price GSP.

For national economies, a variety of techniques are available for deflating current-price GNP in order to obtain a measure of constant-price GNP. The adoption of a particular deflation technique often depends on the way in which current-price estimates of GNP have been derived. The usual constant price data are for expenditure on GNP at market prices and its components.²² This data purports to show changes in real personal consumption, real expenditures, and real capital formation. The constant price data are obtained by deflating the current expenditure data for specific goods and services by appropriate price indexes, or in some cases by using direct quantity measures for the changes in particular categories of goods and services. Since our current-price estimates of GSP are not derived by summing expenditure items, the deflation technique just described is not suitable for our purpose.

Current-price estimates of GNP are often derived by summing accrued factor incomes earned and nonfactor costs incurred in the

22. This method to obtain constant-price estimates of GNP and its components is employed in *Australian National Accounts*. See Appendix B, *ANA*, 1970-71.

production process.²³ This estimation method can give rise to problems of deflation. For the current-price estimates of GNP thus derived (as the sum of factor payments and nonfactor costs of production) are not directly convertible to constant-price estimates because the components (employee compensation, profits, interest, etc.) cannot be properly regarded as the product of a quantity and a unit price. Since our current-price estimates of GSP are derived in a way which is equivalent to the summation of factor payments,²⁴ this deflation problem will also arise in our case.

An alternative deflation technique is available when the current-price estimate of GNP is derived, on an industry-by-industry basis, as the sum of each industry's contribution to the nation's total output of goods and services. Because an industry's gross product or value added represents its unduplicated contribution to total output, it may be measured as the value of production less the contribution to its production made by other industries, i.e. materials and services purchased from other industries. On the basis of this definition of industry gross product as the difference between output and input of materials, business services, and other items, estimates of industry real product can be derived by the double-deflation method. In this method, each industry's current-price sales (including inventory change) and purchases of intermediate materials and services

23. See Section 5.3 on alternative approaches to derive GSP.

24. Recall that in Section 5.4, our current-price estimates of GSP are derived by extending some income-components of the personal income series so as to cover all income components of GSP.

are deflated separately and the difference between the estimates of constant-price production and cost of intermediate products, is constant-price industry gross product. However, to be operative, this double deflation method requires knowledge of the inputs into each industry and their prices, as well as the prices of each industry's output. In practice, it is not always possible to develop industry-real-product measures by this method and various alternative methods are used.

For Tasmania, gross state product at constant prices is difficult to calculate owing to the absence of suitable Tasmanian price indices. A consumer price index has been used as a general deflator in some regional studies,²⁵ and is often considered a suitable deflator for various expenditure items and for personal income. However, it is not a satisfactory deflator for GSP which is a measure of output. Instead, we have chosen to deflate the Tasmanian GSP at current prices by Australian price indices. The price indices used were all obtained from a publication of the *Commonwealth Bureau of Census and Statistics*.²⁶ In this publication, constant-price

25. See, for example, the *Philadelphia model* in Chapter Three.

26. See Supplements to ANA, June 1969, *Ibid*.

estimates of gross product by industry were derived from the current-price estimates by the double deflation method described above. By dividing the former into the latter one is able to obtain a price index for each industry. These price indexes have been reproduced in Table A5.4 in the Appendix.

Since our price deflators are now available on an industry basis, we can derive not only the constant-price gross state product aggregate but also its industry components. Before we can do this, we must first break down our current-price estimates of GSP into its industry components. To do this, we require an industry distribution of the series, incomes received by persons from current production (previously defined as consisting of wages, salaries and supplements, income of unincorporated enterprises) and entrepreneurial income.²⁷ Such an industry distribution is available for the year 1964-65 and we have calculated the distribution for other years by applying the Australian distributions. These figures are presented in Table A5.5 in the Appendix.

Having obtained our industry subdivisions of incomes-received by person from current production, we can now apply the income-approach to estimate GSP and its industry subdivisions at current-prices. These figures are presented in Table A5.2 in the Appendix. These current-price estimates of industry gross product are later divided by the relevant price deflators in Table A5.4 to give constant-price estimates of GSP and its industry subdivisions. These constant-price estimates are presented in Table A5.3 in the Appendix.

27. See Section 5.4 above on how we estimated GSP for Tasmania using the income-approach.

CHAPTER SIXA REGIONAL EMPIRICAL MODEL FOR TASMANIA6.1 Introduction

In Chapter Four we came to the conclusion that, having regard to data requirements, the only types of REM which it would be feasible to construct for the Tasmanian economy at the present time are a REMM and REBM. Having reached that conclusion, we will now act accordingly. In this chapter, a REMM will be constructed and described while in Chapter Seven, we shall construct two REBM.

The REMM to be developed in this chapter is designed for forecasting three Tasmanian aggregates: gross state product, total personal income, and total employment. It comprises three regression equations, each of which relates a particular Tasmanian aggregate (the regressand) to a number of Australian (and some overseas-sector) economic indicators (the regressors). The regressors to be used in the final forecasting equations were chosen from a set of eighteen potentially relevant explanatory variables. These eighteen variables are discussed in Section 6.2. The method used to decide which of these variables will be used in the three equations of our REMM was stepwise regression. In this method, the independent variables are introduced into or removed from the regression one at a time in a "step-wise" manner. The decision as to whether to accept a variable or not is made on the basis of the influence of this variable upon the residual variance of the equation. A more detailed description of this method and the results of the experiments performed using step-wise regression procedure is given in Section 6.3 below.

Having decided which independent variables were to be used in the three forecasting equations of our REMM we then experimented with the various lag structures in the hope of improving its performance. The various lag-experiments performed are described in Section 6.4. Finally, in Section 6.5 we present some conclusions.

6.2 Choice of Variables

The first step in the development of our REMM was to decide on the variables to be included. As regards the *dependent* variables we singled out three Tasmanian aggregates as representative indicators for the State. They are respectively gross state product GSP, total employment TEMP, and total personal income TPI. The significance of GSP has already been discussed in Chapter Five and will not be considered again here. Total employment can be regarded as an important indicator for reflecting the general economic conditions of the State. Measures of productivity, unemployment, and so on, can be computed from employment estimates. Also, the comparison of economic growth can be made on the basis of employment rather than the more common indicator, state or personal income. The third dependent variable chosen is total personal income. This variable is generally regarded as a good measure of "economic welfare" for the State, and when set alongside statistics of population gives a measure of the "standard of living". Thus jointly, these three Tasmanian variables provide a good basis for the type of economic analysis which we are to undertake.

As a first step in compiling our set of potentially relevant *independent* variables we listed those commonly used in the sample of regional econometric models discussed in Chapter Three. Examination of these REM shows that the commonly-used independent national variables are those listed in Table 6.1.

Table 6.1

Commonly-Used Independent National Variables

<u>Line</u>	<u>Symbol</u>	<u>Variable</u>	<u>Models* Using Variable</u>
1.	GNP	Gross National Product	all models
2.	GNP _i	Expenditure Components of GNP: e.g. Consumption Expenditure, Private Investment	Michigan and California models
3.	DE	Defense Expenditure	Hawaii and California models
4.	NDE	Non-Defense Government Expenditure	Hawaii
5.	TE	Tourist Expenditure	Hawaii

* "Models" refers to models discussed in Chapter Three except for "California model" [79], which is included for completeness.

We considered each of the variables listed in Table 6.1 in turn. It seemed clear that defense expenditure, though important to the income-generation process of both the Californian and the Hawaiian economies, is not an important variable in the Tasmanian context. Tourism is an important income-generating activity in Tasmania and so the variable, tourist expenditure in Tasmania, should be a potentially relevant variable. Unfortunately, the lack of information on this particular variable made it impossible to include it in our

analysis. We were, therefore, left with GNP and the various expenditure components of GNP to be considered in compiling our list of potentially relevant independent variables. These seemed to be valid candidates, and accordingly, GNP (gross domestic product in Australian statistical terms) and six expenditure components were included (variables (V8) through (V13) in Table 6.2, p. 156.

Having made our selection from the variables listed in Table 6.1, we next added seven other variables representing the supply side of the Australian economy (variables (V1) through (V7)), four variables from the overseas sector (variables (V14) through (V17)), and one income variable. Thus, by this simple process, we made up a list of eighteen potentially relevant independent variables.

We must now consider the problem of getting the necessary data for the eighteen chosen independent variables. There are in fact two ways of solving this problem. One way is to obtain data on the required national variables directly from the data base of a national econometric model that has already been constructed. This can be done when the regional model under study is "linked-up" with a related national econometric model.¹ This procedure when undertaken can help the regional model-builder not only in the estimation stage where he can obtain data on the national variables he requires directly from the data base of the national model, but also in the forecasting stage where the forecast values of the relevant national variables can be obtained directly from the solutions of the national model. The possibility of linking up our Tasmanian REM to one of the existing macroeconomic models for

1. On this point, see our discussions on p. 19, Section 2.3.1 above.

Australia was considered. However, it was concluded that the technical problems involved would make such a linking-up impracticable in our case. Although a number of national macroeconomic models are now in operation in Australia, the data-base, and the manipulations of these models to get the required solutions are not directly accessible to an outsider and negotiations with those directly involved in the development of these national models was not considered feasible. Accordingly, we decided to adopt the second way of solving this problem, namely by relying on *Australian National Accounts* and other publications of the *Commonwealth Bureau of Census and Statistics* (now called the Australian Bureau of Statistics) for our data requirements. From these sources, time series for our list of eighteen potentially relevant variables as indicated in Table 6.2 on page 156 have been compiled. CBCS publications were the source of the time series used for two of our *dependent* variables also. The series for total personal income was taken from *Australian National Accounts* while that for total employment was taken from *Employment and Unemployment*. The series used for gross state product was, of course, taken from Chapter Five. The complete set of time series used for the three dependent variables and the eighteen potentially relevant independent variables is shown in Data Table A6 in the Appendix. It will be seen that the sample period is from 1948-49 to 1971-72.

As mentioned in Section 6.1, eighteen regressors are far too many to be included at the one time when the sample period is as short as ours. For this and other reasons we want to cut down

Table 6.2

Potentially Relevant Independent Variables

<u>No. of Variable</u>	<u>Symbol</u>	<u>Description of Variable</u>	<u>Source</u>
V1	AUSEMP	Total Civilian Employment	2 (see
V2	UNEMPL	Persons on Unemployment Benefits	2 below for key)
V3	GDP	Gross Domestic Product (\$m.)	1
V4	MGFPRD	Gross Manufacturing Product (\$m.)	1
V5	GNFPRD	Gross Non-Farm Product (\$m.)	1
V6	METPRD	Production of Meat, quantity in tons	3
V7	WOLPRD	Production of Wool, quantity in lbs.	3
V8	Δ Stock	Physical Change in Stocks (\$m.)	1
V9	PCONSP	Total Private Consumption Expenditure (\$m.)	1
V10	GCONSP	Total Government Consumption Expenditure (\$m.)	1
V11	INVDWL	Investment in Dwellings (\$m.)	1
V12	INVOTH	Investment in Other Categories (\$m.)	1
V13	INVGOT	Government Investment (\$m.)	1
V14	PIDXUK	Production Index in the U.K.	4
V15	NINCUK	National Income U.K. (£m.)	4
V16	EXPORT	Value of Total Australian Exports (\$m.)	1
V17	IMPORT	Value of Total Australian Imports (\$m.)	1
V18	AUSPIN	Australian Total Personal Income (\$m.)	1

Source: 1. *Australian National Accounts* (CBCS, Canberra)
 2. *Employment and Unemployment* (CBCS, Canberra)
 3. *Primary Industries* (CBCS, Hobart)
 4. *Quarterly Summary of Statistics* (CBCS, Canberra)

the number of regressors in our forecasting equations by eliminating those which are statistically insignificant. A systematic method of doing this is the method known as Stepwise Regression and this is the method which we employed.

Stepwise Regression belongs to a class of statistical procedures which have been proposed for variable selection in multiple regression.² These procedures deal with the problem : given a large set of potential predictors, to select the "best" subset. This is precisely the problem which arises in the course of developing our REMM for Tasmania. Specifically, we are confronted with a list of eighteen potentially relevant independent variables and find it impossible to include them all because of the smallness of our sample size. We wish, therefore, to select the "best" subset. In our stepwise regression computations, the eighteen potential independent variables were screened, one by one, by an automatic screening computer routine to decide which one was to be kept in the final forecasting equation. In a "stepwise" manner, an independent variable was entered into the forecasting equation when it was found to be statistically significant, or was removed when it was found not to be so.

Results of our Stepwise Regression experiments are presented in the next section, but before we move on to discuss these

-
2. Other procedures now available for selecting variables in multiple regression analyses include all possible regressions, the backward elimination method, and the forward selection method. An excellent account of these methods appears in N. R. Draper and H. Smith [15].

results a word of warning on the use of Stepwise Regression in econometric research is in order. In the first place, Stepwise Regression results indicate nothing more than particular associations between the independent variables and the dependent variable under study; they do not of themselves suggest anything about causality, i.e. the results cannot be used to make inferences about any structural relationships which might have generated the data used. In the second place, when there is multicollinearity among the independent variables Stepwise Regression might easily exclude significant independent variables from the final regression equation. In selecting variables for inclusion in the regression equation, if any of the independent variables are intercorrelated so that they affect the dependent variable jointly as well as independently, the technique of Stepwise Regression attributes all of the joint effect to the variables selected for inclusion. Thus, some variables rejected by the analysis as not adding significantly to the R^2 for a particular relationship may, in fact, have an important influence on the dependent variable. And finally, it must be stressed that fruitful use of Stepwise Regression lies only in the initial exploratory stage of a continuing process of experimentation involving relationships about which little is known, and that this process must be supplemented by further empirical testing and theoretical reasoning. For this empirical approach is never meant to replace the need for sound theoretical reasoning from which plausible hypotheses are formulated and tested. Failing this, the use of Stepwise Regression becomes opportunistic and may be little more than casual empiricism.

6.3 Stepwise Regression Results

With the help of the available stepwise computer programme³ we have performed the following stepwise regression experiments. Each of the three Tasmanian aggregates (gross state product, total personal income and total unemployment) was regressed in turn on all the eighteen potentially relevant independent variables (described in Table 6.2, p. 156). The stepwise procedure then picked out the significant independent variables to form the final forecasting equation. The operation of the procedure requires that two critical F-values be chosen from the F-table in advance. The first (called the "F-in" value) is used to set the lower limit for the entry of variables, and the second (called the "F-out" value) is used for the exclusion of variables from the forecasting equation. Throughout our experiments, the critical F-in value was fixed equal to the F-out value at 4.38,⁴ and this critical F-value was unchanged in each step of the stepwise procedures (i.e. ignoring the changing degrees of freedom when new independent variables enter or when old variables are removed from the final forecasting equation).

In order to pick the best functional form for the final forecasting equation, data in absolute values, first differences, and in (common) logarithms have been tried with the stepwise regression

-
3. The programme used, *STEPWISE REGRESSION*, U2476, was written by D. W. Challen, Commerce Department, University of Tasmania.
 4. This corresponds to the F-value with 1 and 19 degrees of freedom at the 5% critical point; see Table 7 in R. J. Wonnacott and T. H. Wonnacott [62]. In these experiments, the number of observations was ($n = 24$) and the number of independent variables to be included in the final prediction equation was assumed to be $k = 4$, thus making the degrees of freedom in the denominator equal to: $n - k - 1 = 19$.

Table 6.3

Summary of Stepwise Regression Results *

		\bar{R}^2	D-W
A. GROSS STATE PRODUCT (GSP)			
1.	GSP = 33.84 + .105 MGFPD - .332 NINCUC (6.0) (11.4) (2.1)	.996	.92
2.	ΔGSP = 5.38 + .017 ΔGDP (1.34) (6.88)	.678	1.50
3.	log GSP = 1.172 - .494 log AUSEMP - .081 log INVOTH - .032 log UNEMPL + 1.199 log MGFPD (2.23) (-3.29) (-4.46) (-3.73) (24.64)	.997	1.26
B. TOTAL PERSONAL INCOME (TPI)			
1.	TPI = 8.97 + .035 PCONSP (2.33) (103.1)	.998	1.59
2.	ΔTPI = 5.81 + .020 ΔAUSPIN (2.0) (9.68)	.808	2.58
3.	log TPI = -2.01 + .727 log GDP + .605 log PCONSP - .209 log NINCUC - .028 log INVOTH - .44 log PIDXUK (-7.7) (3.5) (3.05) (-2.6) (-2.1) (-3.3)	.998	2.11
C. TOTAL EMPLOYMENT (TEMP)			
1.	TEMP = 3.0 + .032 AUSEMP - .003 EXPORT (.99) (20.6) (-3.5)	.995	1.42
2.	ATEMP = .87 + .0198 ΔAUSEMP - .005 ΔMETPRD (1.9) (4.9) (-2.3)	.573	2.52
3.	log TEMP = -1.1 + .776 log AUSEMP + .068 log GCONSP - .06 log EXPORT (.6) (14.0) (5.12) (-2.97)	.996	1.94

* The figures in parentheses are (partial) t-ratios. These are the positive square roots of the partial F-values, or what are called partial determination coefficients by A. Goldberger, *op. cit.*

programme. The results of our stepwise regression experiments are summarized in Table 6.3 on p. 160. The following points deserve comment. Firstly, both when the data are expressed in absolute values and when they are expressed in logarithms, near-perfect fit (i.e. \bar{R}^2 in excess of .99) results for all three final equations. The equations based on logarithmic data contain more independent variables than the ones using data in absolute values. In this respect, the equations using data in absolute values would be preferred because they have produced the same fit with less regressors. However, judging from the values of the Durbin-Watson statistic (d), the results seem to point to the reverse direction. The equations using absolute values tend to have lower values for this statistic, and in two out of the three cases (excepting the one for personal income) $d < d_n$, the critical lower limit. This suggests that these equations have significant positive autocorrelation in their residual.

Secondly, judging from the values of the partial t-ratios (t) for the regression coefficients, both the logarithmic and the absolute value forms of the equations tend to identify the same variable as the most significant. For instance, for gross state products, the most significant explanatory variable is gross manufacturing product MGFFRD with ($t = 11.4$) for the absolute value form and ($t = 24.64$) in the logarithmic form. The same results apply to both total personal income (where the most significant explanatory variable is private consumption in Australia PCONSP) and total employment (where the most significant explanatory variable is the Australian Total Employment AUSEMP). So overall, the results

for these two functional forms are similar, and had it not been for the rather unsatisfactory values of the Durbin-Watson statistic, one would prefer the absolute-value form to the logarithmic form.

The results are somewhat different for the equations using first differences. In the first place, the first-difference forms tend to give poorer fit (although this result is hardly unexpected since equations using first differences almost always produce poorer fit). Secondly, the equations based on first-difference data tend to identify a different regressor. In particular, the first-difference forms suggest that the best (most significant) explanatory variable is the national variable which corresponded to the dependent variable. Thus, for gross state product, the only regressor entering into the forecasting equation is gross domestic product. This applies also to the equations for total personal income and total employment where the corresponding Australian personal income and Australian employment are the most significant explanatory variables. Thirdly, the first-difference forms seem to fare best in regard to the Durbin-Watson statistic. In all three equations, $d > d_u$, the critical upper limit, indicating the absence of autocorrelated residuals.

On the whole, the results obtained from our stepwise regression experiments were highly satisfactory. Although the logarithmic and the absolute-value forms included different regressors in their respective forecasting equations, they tended to identify the same, most significant one. Further, with only one or at most two regressors, the absolute-value form can explain over 99% of the variations in the dependent variable. The only unsatisfactory point

about these equations is their low Durbin-Watson statistic ($d < 1.5$). We will see in the next section (6.4), where we experiment with different lag-structures, whether this unsatisfactory feature can be improved upon.

6.4 Experiments on the Lag Structure

From the last section we have seen how the method of Stepwise Regression has assisted us to identify the national indicators which are most closely associated with particular Tasmanian variables. But it must be pointed out that in the analysis undertaken so far it has been assumed that the Tasmanian variable at time t is influenced only by the contemporaneous values of certain national variables. Now, in this section we will assume that the Tasmanian variable at time t is related not only to the current value but also to past values of the national indicators in question. If this assumption is valid, our empirical model could be improved by imposing a lag structure. Our experiments on the lag structure were conducted within the framework of the general distributed-lag model:

$$(6.1) \quad y_t = \sum_{i=0}^{\infty} \beta_i x_{t-i} + e_t,$$

where y is the dependent variable, x the independent variable,

e a random disturbance and the β 's a set of constants.

Clearly (6.1) cannot be estimated as it stands since it contains an infinite number of parameters. Two ways of reducing the estimation problem to manageable proportions are to impose a

geometrically declining weight pattern on the β 's and to assume that the number of lags is finite, i.e. that all β 's are zero beyond a certain point. Both approaches were tried. The first is discussed in the sub-section (6.4.1) and the second in sub-section 6.4.2.

6.4.1 Geometrically Declining Weights

One way of dealing with the above-mentioned problem of estimating (6.1) is to apply the so-called Koyck-transformation. In this approach, the coefficients β_1 of (6.1) are assumed to decline geometrically beginning with the first lag. Thus,

$$(6.2) \quad y_t = \beta_0 \sum_{i=0}^{\infty} \lambda^i x_{t-i} + e_t$$

where $0 < \lambda < 1$. Equation (6.2) is then lagged one period and multiplied by λ . The resulting equation is then subtracted from equation (6.2) to give:

$$y_t - \lambda y_{t-1} = \beta_0 x_t + (e_t - \lambda e_{t-1}),$$

which can be rearranged as:

$$(6.3) \quad y_t = \beta_0 x_t + \lambda y_{t-1} + u_t,$$

where $u_t = e_t - \lambda e_{t-1}$. Hence we need now estimate only two parameters, β_0 and λ . However, Koyck observed that the use of ordinary least squares to estimate the parameters of (6.3) gives inconsistent

estimates of the parameters β_0 and λ and he proceeded to develop a scheme for computing consistent estimates. Klein⁵ later considered the same problem and developed another method for producing consistent estimates of β_0 and λ . But before we discuss the Klein-method we will digress briefly to discuss two extensions of the above Koyck-transformation procedure.

The first extension allows for more than one explanatory variable. To illustrate, let us take the case of two explanatory variables. The equation corresponding to (6.2) is now:

$$(6.4) \quad y_t = \beta_1 \sum_{i=0}^{\infty} \lambda_1^i x_{1,t-i} + \beta_2 \sum_{j=0}^{\infty} \lambda_2^j x_{2,t-j} + e_t,$$

where $0 < \lambda_1, \lambda_2 < 1$. We can simplify this by applying Koyck-transformation twice in succession. In the first transformation, we have:

$$(6.5) \quad y_t - \lambda y_{t-1} = \beta_1 x_{1,t} + \beta_0 [x_{2,t} + (\lambda_2 - \lambda_1)x_{2,t-1} + \lambda_2(\lambda_2 - \lambda_1)x_{2,t-2} + \lambda_2^2(\lambda_2 - \lambda_1)x_{2,t-3} + \dots] + e_t - \lambda e_{t-1}.$$

Next, we repeat the Koyck-transformation by lagging (6.5) one period, multiplying it by λ_2 , and subtracting the resulting equation from (6.5) to get:

5. L. R. Klein [107].

$$\begin{aligned}
 (6.6) \quad y_t = & \beta_1 x_{1,t} + \beta_2 x_{2,t} - \beta_1 \lambda_2 x_{1,t-1} - \beta_2 \lambda_1 x_{2,t-1} \\
 & + (\lambda_1 + \lambda_2) y_{t-1} - \lambda_1 \lambda_2 y_{t-2} \\
 & + [e_t - (\lambda_1 + \lambda_2) e_{t-1} + \lambda_1 \lambda_2 e_{t-2}]
 \end{aligned}$$

Hence, we now have six regressors instead of two and hence six coefficients for evaluating the four parameters of the model, i.e. $\beta_1, \beta_2, \lambda_1, \lambda_2$. Because of this difficulty, this extension of the basic Koyck-transformation has not been pursued in this study.

The second extension allows the geometrical decline of the weights to start from the k^{th} lag instead of the first. The equation corresponding to (6.2) is now:

$$(6.7) \quad y_t = \sum_{i=0}^{k-1} \beta_{i+1} x_{t-i} + \beta_{k+1} \sum_{j=0}^{\infty} \lambda^{j+1} x_{t-k-j} + e_t$$

It can be seen that the Koyck-transformation of (6.7) gives

$$\begin{aligned}
 (6.8) \quad y_t = & \beta_1 x_t + [(\beta_2 - \lambda \beta_1) x_{t-1} + (\beta_3 - \lambda \beta_2) x_{t-2} + \dots] \\
 & + \lambda y_{t-1} + (e_t - \lambda e_{t-1}) \\
 = & \beta_1 x_t + \sum_{i=1}^{k-1} (\beta_{i+1} - \lambda \beta_i) x_{t-i} + \lambda y_{t-1} + (e_t - \lambda e_{t-1})
 \end{aligned}$$

Relationships of the form of (6.8) were estimated for Tasmania with GSP as y and MGFPD as x , TPI as y and PCONSP as x and TEMP as y and AUSEMP as x .⁶ In each case the values of k tried were from one to

6. The explanatory variables in these relationships were selected on the basis of our stepwise regression experiment. See Section 6.4, Summary Table 6.3 on p. 160 above.

Table 6.4

Distributed-Lag Experiment A: Geometrical Decline From the k^{th} Lag ^a

Number of Dependent Estimation Variable		Estimate of Intercept	Estimated Coefficient of					\bar{R}^2	D-W
			GSP _{t-1}	MGFPRD _t	MGFPRD _{t-1}	MGFPRD _{t-2}	MGFPRD _{t-3}		
1.	GSP _t	22.99 (2.38)	0.445 (2.11)	0.066 (3.82)	-0.034 (-1.18)	0.053 (2.05)	-0.040 (-2.19)	.997	1.90
2.	GSP _t	30.66 (3.04)	0.301 (1.34)	0.069 (3.56)	-0.023 (-0.72)	0.014 (0.66)		.997	1.77
3.	GSP _t	28.77 (3.02)	0.344 (1.63)	0.068 (3.58)	-0.013 (-0.47)			.997	2.01
4.	GSP _t	30.81 (3.73)	0.281 (1.78)	0.061 (5.08)				.997	1.91
			TPI _{t-1}	PCONSP _t	PCONSP _{t-1}	PCONSP _{t-2}	PCONSP _{t-3}		
5.	TPI _t	17.27 (2.46)	-0.161 (-0.63)	0.035 (3.36)	0.012 (0.74)	0.007 (0.41)	-0.016 (-1.69)	.998	1.83
6.	TPI _t	17.10 (2.28)	-0.043 (-0.16)	0.035 (3.15)	0.015 (0.88)	-0.016 (-1.64)		.997	2.24
7.	TPI _t	17.96 (2.29)	-0.104 (-0.38)	0.041 (3.58)	-0.003 (-0.18)			.997	1.82
8.	TPI _t	17.94 (2.36)	-0.131 (-0.57)	0.039 (5.45)				.997	1.74
			TEMP _{t-1}	AUSEMP _t	AUSEMP _{t-1}	AUSEMP _{t-2}	AUSEMP _{t-3}		
9.	TEMP _t	10.68 (2.87)	0.569 (2.47)	0.028 (5.19)	-0.012 (-1.23)	0.004 (0.47)	-0.010 (-1.69)	.995	1.96
10.	TEMP _t	9.04 (2.37)	0.562 (2.30)	0.026 (4.65)	-0.009 (-0.89)	-0.006 (-0.88)		.994	1.84
11.	TEMP _t	8.58 (2.29)	0.529 (2.21)	0.027 (5.11)	-0.015 (-1.93)			.994	1.74
12.	TEMP _t	12.78 (3.88)	0.197 (1.09)	0.021 (4.58)				.993	1.08

^a Figures in parentheses are t-ratios.

three inclusive, and the sample period for the estimations was from 1952-53 to 1971-72 (i.e. 20 observations). The method of estimation used was ordinary least squares. The results are summarized in Table 6.4.

Referring to the figures in Table 6.4 above, it can be seen that one cannot pick the best distributed-lag form for any one of the three Tasmanian aggregates on the basis of either the \bar{R}^2 values or the value of the D-W statistics. We therefore pick the best form on the basis of the value of the t-ratios alone. Accordingly, we have chosen equation (4) for GSP and equation (12) for TEMP. No equation has been chosen for TPI because the coefficients for both the lagged dependent variables are mostly not significant.

Returning from our digression, we will now take up the discussion of the Koyck-Klein method of producing consistent estimates of β_0 and λ in (6.3). As mentioned before application of ordinary least squares to (6.3) yields inconsistent estimates for β_0 and λ .⁷

Recall that (6.3) is:

$$y_t = \beta_0 x_t + \lambda y_{t-1} + (e_t - \lambda e_{t-1}).$$

The procedure suggested by Koyck for producing consistent estimates of β_0 and λ consists of two stages. The ordinary least squares estimates of β_0 and λ are obtained first and the second stage which involves the solution of a quadratic equation in λ . This procedure

7. Inconsistency arises because of the autocorrelated errors in (6.3) and because of the appearance of the lagged dependent variable as a regressor.

is being superseded, however, by Klein's method which aims at direct instead of two-stages estimation of β_0 and λ . Klein's approach is to treat (6.3) as an "error-in-variables" model by rewriting it as:

$$(y_t - e_t) = \beta_0 x_t + \lambda(y_{t-1} - e_{t-1}),$$

where the e 's are regarded as observation errors. For the special case where e is serially independent and the e_t follow a normal distribution, Klein shows that a consistent (maximum-likelihood) estimate of λ is obtained by solving the following quadratic in λ :

$$\begin{aligned} \lambda^2 \left[\frac{(\sum x_t y_t)(\sum x_t y_{t-1})}{\sum x_t^2} - \sum y_t y_{t-1} \right] \\ + \lambda \left[\sum y_t^2 - \sum y_{t-1}^2 + \frac{(\sum x_t y_{t-1})^2 - (\sum y_t x_t)^2}{\sum x_t^2} \right] \\ + \left[\sum y_t y_{t-1} - \frac{\sum x_t y_{t-1} \cdot \sum y_t x_t}{\sum x_t^2} \right] = 0 \end{aligned}$$

A consistent estimate of β_0 is then given by:

$$\hat{\beta}_0 = \frac{-\hat{\lambda} \sum x_t y_{t-1} + \sum x_t y_t}{\sum x_t^2} . \quad 8$$

8. See L. R. Klein, *op. cit.*, pp. 555-556. For a description of the derivation, also see J. Kmenta [35], pp. 483-484.

Relationships of the form of (6.3) with an intercept term added were estimated by the Klein method for Tasmania with GSP as y and MGFPD as x, TPI as y and PCONSP as x and TEMP as y and AUSEMP as x, in each case both with absolute-value data and with logarithmic data.⁹ A relationship of the above form with TPI as y and GDP as x was also estimated with logarithmic data. These seven estimations for all of which the sample period was from 1948-49 to 1970-71 are set out in Table 6.5.

One can see that the consistent estimates as presented in Table 6.5 differ from the corresponding estimates presented in Table 6.4 above when ordinary least squares was used. See, for example, the estimates in Estimation (1) of Table 6.5 and the corresponding estimates in Estimation (4) of Table 6.4; the estimates of Estimation (3) in Table 6.5 and the estimates of Estimation (12) in Table 6.4. As mentioned before, the estimates in Table 6.4 were inconsistent estimates and, for this reason, estimates in Table 6.5 are preferred in the selection of final forecasting equations. This point will be discussed in the last section of this chapter.

9. Note that Klein's method cannot handle either of the extensions of the basic Koyck-transformation approach discussed above. Consequently in each equation we could include only one of the independent variables suggested by our Stepwise Regression exercise and could not "free" the first k distributed lag weights. The programme used for our computations, Koyck-Klein Distributed Lags II, U2376 was written by D. W. Challen, Commerce Department, University of Tasmania.

Table 6.5

Distributed Lag Experiment B: Klein Estimation

<u>Number of Estimation</u>	<u>Estimated Relationships</u>	<u>RSS</u> *
1.	$GSP_t = 20.7 + .0443 MGFPD_t + .507 GSP_{t-1}$	1782.9
2.	$TPI_t = 10.8 + .0322 PCONSP_t + .088 TPI_{t-1}$	1248.8
3.	$TEMP_t = 4.6 + .00936 AUSEMP_t + .662 TEMP_{t-1}$	40.19
4.	$\log GSP_t = 1065 + .531 \log MGFPD_t + .394 \log GSP_{t-1}$	465959.1
5.	$\log TPI_t = -8270 + .798 \log PCONSP_t + .164 \log TPI_{t-1}$	314613.0
6.	$\log TPI_t = -2930 + .620 \log GDP_t + .297 \log TPI_{t-1}$	235605.0
7.	$\log TEMP_t = -3110 + .359 \log AUSEMP_t + .594 \log TEMP_{t-1}$	55929.6

* RSS represents residual sum of squares.

6.4.2 Almon Weights

A second way of reducing the estimation problem of (6.1) to manageable proportions is to assume that after a certain lag all β 's are zero and then to use the Almon method to estimate the rest.¹⁰ To apply this method two parameters, n and q , must be specified in advance. The former is the length of the maximum lag while $(q + 1)$ is the degree of polynomial on which the β 's to be estimated are assumed to lie.

Two Almon-lag experiments were performed with sample period 1948-49 to 1971-72 (i.e. 24 observations).¹¹ In the first experiment (henceforth named Almon-Lag Experiment (1)), altogether six different data-blocks were used, each containing 24 observations on the dependent variable and on one explanatory variable (named the lagged-variable from now on) chosen as a result of the stepwise regression experiments described earlier in Section 6.3. With each data-block nine different pairs of values for q and n were tried. Thus in this experiment fifty-four distinct distributed lag relationships were estimated by the Almon method. The six data-blocks and the various pairs of values of q and n are shown in Table 5.6 which also gives the fifty-four Almon estimations.

From the results presented in Table 6.6, the following features of Almon-Lag Experiment (1) are observed. Firstly, all

10. For an account of this method see S. Almon [66], J. Kmenta, *Ibid.*, Ch. II, pp. 492-495.

11. The programme used in this experiment, *ALMON DISTRIBUTED LAGS, U2090* was written by K. Herrmann, Commerce Department, University of Tasmania.

Table 6.6

Distributed Lag Experiment C: Almon-Lag Experiment (1)

Number of Estimation	Data Block 1					Data Block 3				
	Dependent Variable: GSP Lagged Variable: MGFFRD					Dependent Variable: TEMP Lagged Variable: AUSEMP				
	<u>n</u>	<u>q</u>	<u>\bar{R}^2</u>	<u>D-W</u>	<u>MSR</u>	<u>n</u>	<u>q</u>	<u>\bar{R}^2</u>	<u>D-W</u>	<u>MSR</u>
1	4	2	.997	1.34	81.1	4	2	.991	.96	1.95
2	5	2	.997	1.57	78.2	5	2	.991	1.36	1.83
3	6	2	.997	1.90	62.5	6	2	.992	1.50	1.57
4	7	2	.997	2.08	60.8	7	2	.993	1.51	1.30
5	8	2	.997	1.95	62.9	8	2	.992	1.18	1.39
6	5	3	.996	1.54	77.4	* 5	3	.993	1.07	1.37
7*	6	3	.997	1.91	59.9	6	3	.993	1.35	1.33
8	7	3	.997	2.15	55.4	7	3	.994	1.51	1.13
9	8	3	.997	2.00	54.9	8	3	.994	1.50	1.02
Number of Estimation	Data Block 2					Data Block 4				
	Dependent Variable: TPI Lagged Variable: PCONSP					Dependent Variable: log GSP Lagged Variable: log MGFFRD				
	<u>n</u>	<u>q</u>	<u>\bar{R}^2</u>	<u>D-W</u>	<u>MSR</u>	<u>n</u>	<u>q</u>	<u>\bar{R}^2</u>	<u>D-W</u>	<u>MSR</u>
1*	4	2	.998	2.09	39.0	4	2	.994	1.05	17548
2	5	2	.998	2.17	48.4	5	2	.994	1.16	16182
3	6	2	.997	1.93	53.1	6	2	.995	1.67	10213
4	7	2	.997	2.22	48.1	7	2	.996	2.18	7174
5	8	2	.998	2.07	43.6	8	2	.996	2.00	6155
6	5	3	.998	2.23	38.7	* 5	3	.993	1.21	16043
7	6	3	.998	2.19	44.2	6	3	.996	1.67	10213
8	7	3	.998	2.67	38.3	7	3	.996	2.19	7156
9	8	3	.998	2.53	31.6	8	3	.997	2.19	5219
Number of Estimation	Data Block 5					Data Block 6				
	Dependent Variable: log TPI Lagged Variable: log PCONSP					Dependent Variable: log TEMP Lagged Variable: log AUSEMP				
	<u>n</u>	<u>q</u>	<u>\bar{R}^2</u>	<u>D-W</u>	<u>MSR</u>	<u>n</u>	<u>q</u>	<u>\bar{R}^2</u>	<u>D-W</u>	<u>MSR</u>
1	4	2	.997	1.87	6702	4	2	.992	1.03	3051
2	5	2	.996	2.02	9936	5	2	.992	1.44	2955
3	6	2	.995	1.71	10256	6	2	.992	1.57	2713
4	7	2	.996	2.23	7740	7	2	.993	1.40	2254
5	8	2	.997	2.20	4712	8	2	.993	1.44	1985
6 *	5	3	.997	1.91	5516	* 5	3	.994	1.12	2000
7	6	3	.996	1.85	8217	6	3	.993	1.40	2194
8	7	3	.996	2.44	7217	7	3	.993	1.59	1974
9	8	3	.997	2.36	4284	8	3	.994	1.75	1572

combinations of n and q gave near-perfect fit (i.e. \bar{R}^2 in excess of .99 in all cases). From this result, we cannot discriminate one combination from another. Secondly, the values of the D-W statistic are found to be increased with increasing values of n . Thirdly, the MSR-values are found to fall with increasing values of n , and for some combinations of n and q , a minimum MSR-value occurs when the value of n is around 7. In most other instances, however, the MSR-values are found to be falling monotonically with increasing values of n .

We also performed a second Almon-Lag experiment (named Almon-Lag Experiment (2)) with the same sample period as in Experiment (1). Experiment (2) differed from Experiment (1) in that each data-block involved *more than one* lagged variable. Once again the lagged variables in Experiment (2) were chosen from the results of the stepwise regression experiments described in Section 6.3. Not all the significant explanatory variables identified in the stepwise regression experiment were introduced as lagged variables in Experiment (2), however. The procedure adopted was that only those explanatory variables with the highest (partial) t -values (see Table 6.3 on page 160) were introduced as lagged variables; those with lower t -values though significant were included as un-lagged independent variables. The results of Experiment (2) are summarized in Table 6.7 below.

In both Tables 6.6 and 6.7 the preferred estimation for each data-block is marked with an asterisk. These preferred estimations were chosen on the basis of the minimum-MSR criterion and the least n -value criterion. The latter criterion was employed

Table 6.7

Distributed Lag Experiment D: Almon-Lag Experiment (2)

Data Block 1

Dependent Variable: GSP
 Lagged Variable 1: MGFPD
 Lagged Variable 2: NINCUK

Number of Estimation	Lagged Variable No.	n	q	Lagged Variable No.	n	q	\bar{R}^2	D-W	MSR
1	1	4	1	2	4	1	.996	1.31	94.9
2 *	1	4	2	2	4	2	.996	1.39	80.4
3	1	6	1	2	6	1	.995	1.23	117.3
4	1	6	2	2	6	2	.997	2.12	53.6
5	1	6	3	2	6	3	.997	2.06	51.7
6	1	6	4	2	6	4	.998	1.98	33.5

Data Block 2

Dependent Variable: TPI
 Lagged Variable 1: PCONSP

Number of Estimation	Lagged Variable No.	n	q	\bar{R}^2	D-W	MSR
1	1	4	1	.993	.76	162.1
2 *	1	4	2	.998	2.09	39.0
3	1	6	1	.991	.58	218.2
4	1	6	2	.997	1.93	53.1
5	1	6	3	.998	2.19	44.2
6	1	6	4	.998	2.21	41.4

Data Block 3

Dependent Variable: TEMP
 Lagged Variable 1: AUSEMP
 Unlagged Variable 1: METPRD
 Unlagged Variable 2: WOLPRD

Number of Estimation	Lagged Variable No.	n	q	\bar{R}^2	D-W	MSR
1	1	4	1	.988	1.13	2.49
2 *	1	4	2	.993	1.46	1.40
3	1	6	1	.984	.91	3.06
4	1	6	2	.993	1.79	1.26
5	1	6	3	.994	1.78	1.00
6	1	6	4	.997	1.92	.51

because each additional lagged-term means a loss of one observation and this, in turn, throws a further strain on our already short series.

6.5 Conclusion

In this final section, we will present some conclusions on the development of our REMM. As mentioned in the opening section of this chapter, our main purpose in developing a REMM was to provide a means of forecasting three Tasmanian aggregates: gross state product GSP, total personal income TPI, and total employment TEMP. To this end, we have developed three forecasting equations, one for each of these three Tasmanian aggregates.

The development of our REMM involved three steps. As a first step, we compiled time series for our three Tasmanian aggregates as well as for a list of eighteen potentially relevant independent variables (see Table 6.2 for this list). Then in the second step, we selected the most significant independent variables from the list of potential independent variables by means of stepwise regression. In our stepwise regression experiments, we tried three functional forms for our three forecasting equations with data in absolute values, first differences, and logarithms. The form in absolute values was preferred and our main conclusions were as follows: For explaining GSP, the significant independent variables were MGFRRD and NINCUK, the former being the dominant independent variable; for explaining TPI, the only significant independent variable was PCONSP; and for explaining TEMP, the significant independent variables were AUSEMP and EXPORT, the former being the dominant independent

variable.¹² Having selected the independent variables for our three forecasting equations, we then tried in the third and final step to improve our REMM by imposing an appropriate lag-structure on the three forecast equations. Accordingly, we tried four different experiments with the lag structure of our REMM with the following results. In the first lag-experiment (Distributed-Lag Experiment A) where we tried various Koyck-transformation schemes on a distributed-lag model with geometrically declining weights, the weights being assumed to decline from the k^{th} (instead of the first) lag, we found that the basic Koyck-transformation scheme equation (6.3) was preferred for our forecasting equation for both GSP and TEMP, and that no evidence of a distributed lag influence was found for TPI. Thus we concluded from Distributed-Lag Experiment A that our three forecasting equations would be:¹³

$$(6.9) \quad \text{GSP}_t = 30.81 + 0.061 \text{MGFPRD}_t + 0.281 \text{GSP}_{t-1}$$

$$(6.10) \quad \text{TPI}_t = 8.97 + 0.035 \text{PCONSP}_t$$

$$(6.11) \quad \text{TEMP}_t = 12.78 + 0.021 \text{AUSEMP}_t + 0.197 \text{TEMP}_{t-1}.$$

However, as mentioned in Section 6.4.1 equations (6.9) and (6.11) were estimated by ordinary least squares and the estimates so

12. These conclusions stemmed from the results presented in Table 6.3 on p. 160, above.

13. Equations for both GSP and TEMP were extracted from Table 6.4 and equation for TPI from Table 6.3.

derived would be inconsistent. Hence in our second set of lag-experiments (Distributed-Lag Experiment B), we tried to obtain consistent estimates for these two forecasting equations by the Koyck-Klein method. Accordingly, we obtained (extracted from Table 6.5):

$$(6.9a) \quad GSP_t = 20.7 + 0.0443 MGFPD_t + 0.507 GSP_{t-1}$$

$$(6.11a) \quad TEMP_t = 4.6 + 0.00936 AUSEMP_t + 0.662 TEMP_{t-1}$$

In our third and fourth distributed lag experiments (named Distributed-Lag Experiment C and Experiment D respectively) we tried the Almon method of estimating the lag-structure for our REMM by assuming that after a certain lag all the weights in the distributed-lag model were zero. The difference between the two experiments was that in the case of Experiment C each data-block had only one lagged variable whereas in the case of Experiment D there was more than one lagged variable in each data-block. For the various pairs of values of n (maximum length of lag) and q (the degree of polynomial less one) tried, we found that, in Experiment C, the preferred combination for GSP was: $n = 6$, $q = 3$; that for TPI: $n = 4$, $q = 2$; and that for TEMP: $n = 5$, $q = 3$. On the other hand, in Experiment D, we found that the preferred combination for GSP was: $n = 4$, $q = 2$; that for TPI: $n = 4$, $q = 2$; and that for TEMP: $n = 4$, $q = 2$. It appeared that on the basis of these results we can, firstly, generalize the preferred combination

as ($n = 4, q = 2$) for both Experiment C and Experiment D.¹⁴

Looking through the MSR-values for the preferred combination ($n = 4, q = 2$) for the three Tasmanian aggregates in both Experiment C and Experiment D, one can see that the difference is not too great: for GSP, MSR_1 (from Experiment C) = 81.1 and MSR_2 (from Experiment D) = 80.4; for TPI, $MSR_1 = 39.0$ and $MSR_2 = 39.0$; and for TEMP, $MSR_1 = 1.95$ and $MSR_2 = 1.40$. Since we could not improve on the MSR-values by introducing more explanatory variables (i.e. by Experiment D), we can, secondly, generalize by selecting results from Experiment C for our REMM. Thus, from our Almon-lag experiment results it was concluded that our three forecasting equations would be:

$$(6.12) \quad GSP_t = 38.29 + 0.044 \text{MGFPRD}_t + 0.039 \text{MGFPRD}_{t-1} \\ + 0.013 \text{MGFPRD}_{t-2} - 0.009 \text{MGFPRD}_{t-3}$$

$$(6.13) \quad TPI_t = 11.31 + 0.026 \text{PCONSP}_t + 0.020 \text{PCONSP}_{t-1} \\ + 0.001 \text{PCONSP}_{t-2} - 0.012 \text{PCONSP}_{t-3}$$

$$(6.14) \quad TEMP_t = 17.19 + 0.019 \text{AUSEMP}_t + 0.015 \text{AUSEMP}_{t-1} \\ + 0.0004 \text{AUSEMP}_{t-2} - 0.009 \text{AUSEMP}_{t-3}$$

14. Although the preferred combination for GSP and for TEMP in Experiment C was not ($n = 4, q = 2$), we assumed that it was so. This was because of our preference for both a smaller value for both n and q and for a generalized result. Also, it can be seen from Tables 6.6 and 6.7 that the difference in MSR-values is not very large.

Thus, from our distributed-lag experiments we have obtained two sets of forecasting equations each of which is preferred to the other similar equations being tested in the same experiment. The first preferred set (called Set A) comprises the three equations (6.9a), (6.10), and (6.11a), and is obtained from our Geometrically-Declining Weights experiment; whereas the second preferred set (called Set B) comprises the three equations (6.12), (6.13), and (6.14), and is obtained from our Almon Weights experiment. We want now to decide on which of these two is to be used as the set of final forecasting equations for our REMM and our decision is that we prefer Set A to Set B. The most unsatisfactory thing about the equations in Set B is that they have in each of them a negative weight in the last lagged-term and this contradicts our assumption that all the weights should be positive. We have also considered dropping the negative lagged-terms from equations of Set B and using only the positive terms to produce forecasts, but we have found that by doing so the forecasting accuracy of the equations of Set B has significantly decreased. For all these reasons we prefer equations in Set A as the set of final forecasting equations for our REMM and they have been reproduced below for future reference.

$$(6.9a) \quad GSP_t = 20.7 + 0.0443 \text{ MGFPD}_t + 0.507 \text{ GSP}_{t-1}$$

$$(6.10) \quad TPI_t = 8.97 + 0.035 \text{ PCONSP}_t$$

$$(6.11a) \quad \text{TEMP}_t = 4.6 + 0.00936 \text{ AUSEMP}_t + 0.662 \text{ TEMP}_{t-1}$$

CHAPTER SEVENREGIONAL ECONOMIC BASE MODELS FOR TASMANIA7.1 Introduction

This chapter is concerned with the application of the economic base theory to the study of the Tasmanian economy. The importance of the economic base theory lies in the fact that it provides a simple framework for many empirical regional studies. Other theoretical frameworks are, of course, available from which regional models in the tradition of the conventional Keynesian national-income determination model, the national growth model, and others, can be constructed. But these are in general more complicated and demand more data to construct with the result that the construction of these complicated models is often beyond the means that are available to a particular study such as this one. By contrast, the economic base framework from which a Regional Economic Base Model (REBM) can be formulated is simple and the data-requirement for the construction of a REBM not particularly demanding.¹ For these reasons, the economic base theory has become a popular tool in empirical regional studies.

Empirical applications of the economic base theory can generally be classified into two main types. The first application is in short-run multiplier analysis in which the main interest is to obtain estimates of regional multipliers for a particular region.

1. On this point, see our concluding remarks on the feasibility study of the Tasmanian economy in Chapter Four.

These regional multipliers purport to measure the effect on the regional economy of fluctuations in certain basic (or exporting) activities. Two types of regional multipliers may be defined, and which is estimated depends on the unit in which the basic (exporting) activities are measured. When the unit of measurement is employment, i.e. when employment data is used in the analysis, the estimated multiplier is called the employment multiplier; whereas if income is the unit of measurement, the estimated multiplier is called the income multiplier. Very often, the income data required for computing income multipliers is not available and employment data is used instead. In these circumstances, the computed employment multiplier would serve as a proxy for the income multiplier which is being sought.

On the other hand, economic base theory has also been applied in long-run regional growth analyses. In this type of analysis, growth in the region is assumed to be stimulated by growth in its exogenous (or exporting) sector. Empirical studies which have engaged in this type of analysis are concerned mainly with the measurement of the relationship between the growth in the region's exogenous sector and the growth in the regional economy itself.

In this study, we have undertaken both applications of the economic base theory by formulating two separate REBM for Tasmania. The first will be called the short-run REBM to distinguish it from the other which we will call the long-run REBM. The short-run REBM was estimated from employment data for the sample period 1948-49 to 1970-71, whereas the long-run REBM was estimated from income data for the same sample period. From the subsequent analysis it was

found that, on the basis of the estimated short-run REBM, the Tasmanian employment data did not bear out the economic base hypothesis and the consequence of this was that employment multipliers for Tasmania could not be evaluated. On the other hand, our long-run REBM appeared to conform well with the economic base hypothesis, and from this model we were able to estimate the income multiplier for Tasmania. This multiplier was found to be about 3.7. However, as mentioned earlier, our main interest in the long-run REBM was in the measurement of the relationship between the growth in the region's exogenous sector and the growth in the regional economy itself. This matter is explored in detail in Section 7.3.3 below.

We will now describe these two applications of economic base theory to the study of the Tasmanian economy, beginning with the short-run multiplier analysis.

7.2 Short-Run Multiplier Analysis

In this section, we will describe the construction of a short-run REBM for Tasmania. This model is formulated on the basis of the economic base theory using employment as the unit of measurement of basic activities. The model was estimated from data for the period 1948-49 to 1970-71, and from this estimated model we want to compute employment multipliers for the State of Tasmania.

7.2.1 Short-Run Regional Economic Base Model for Tasmania

Our short-run REBM is formulated from economic base theory and so before we present this model it seems appropriate to examine first the application of economic base theory in short-run multiplier analysis.

In essence, the economic base concept is simply a modified form of an old economic concept, the multiplier. According to the economic base concept, activities in the region can be divided into basic and nonbasic categories. An expansion of basic industries sets off a regional multiplier reaction which induces the expansion of domestic industries in the region. Thus an autonomous increase in the basic activities is "multiplied" just as in a national-income determination model investment is multiplied to determine total activity. This multiplier process induced by an autonomous increase in basic activities is explained by Isard, who wrote, "We discover that in the short-run at least certain industries are basic, particularly those that serve national markets. Their fluctuations lead to fluctuations in local income, which in turn induce fluctuations in retail sales and various service trades, which lead to still more indirect fluctuations. In short, the fluctuations of basic industry have a multiplier effect."²

Empirical regional multiplier analysis based on economic base theory often begins with the hypothesis that a stable relationship exists between the basic and the nonbasic activities and that fluctuations in the basic and in the nonbasic activities should move

2. W. Isard [30], p. 183.

in the same direction. Often quoted empirical evidence in support of this hypothesis include the works of J. W. Alexander and that of R. Vining.³ A negative view on the economic base hypothesis can also be found in the works of R. W. Pfouts and R. T. Curtis.⁴

On the basis of this hypothesis a short-run REBM for computing employment multipliers for Tasmania can be formulated as follows:

$$(7.1) \quad E_T = E_B + E_{NB}$$

$$(7.2) \quad E_{NB} = a + bE_T$$

where E_T is total employment in Tasmania; E_B is total employment in the basic industries in Tasmania; E_{NB} is total employment in the nonbasic industries in Tasmania; and a and b are parameters of the model with b being restricted as follows: $0 < b < 1$.⁵ This simple model states, firstly, that total employment in Tasmania is made up of both basic and nonbasic employment (equation (7.1)), and secondly, that nonbasic employment is a linear function of total employment (equation (7.2)).

Before being estimated, the model is turned into its reduced form so that:

3. J. W. Alexander [65]; R. Vining [145].

4. R. W. Pfouts and R. T. Curtis in R. W. Pfouts (ed.) [48].

5. See page 202 below in connection of this restriction.

$$(7.3) \quad E_T = \frac{a}{1-b} + \left(\frac{1}{1-b} \right) E_B$$

$$(7.4) \quad E_{NB} = \frac{a}{1-b} + \left(\frac{b}{1-b} \right) E_B,$$

Since equations (7.1) and (7.2) form an interdependent system, proper estimation procedure calls for the estimation of equations (7.3) and (7.4) rather than (7.2) to avoid the problem of estimating a simultaneous-equations system. The simple model formulated above can now be tested by fitting either equation (7.3) or equation (7.4) by ordinary least squares since these two equations will give identical estimates for the two parameters.⁶ Equation (7.4) is usually preferred for the purpose and is therefore adopted in the following analysis.

To compute employment multipliers, equation (7.4) is fitted by ordinary least squares and from the estimate of the coefficient of E_B an estimate of the ratio of the nonbasic employment to the basic employment, i.e. the so-called nonbasic-basic ratio, is obtained. The employment multiplier, which is defined as the change in total employment for a unit change in total basic employment, is simply equal to one plus the nonbasic-basic ratio.⁷ Symbolically,

6. This is so because the least squares estimate of $\left(\frac{1}{1-b} \right)$ in equation (7.3) is always equal to one plus the estimate of $\left(\frac{b}{1-b} \right)$ in equation (7.4).

7. Notice that the regional multiplier so computed is not to be interpreted in the ordinary sense of the Keynesian income multiplier when applied to a region. The economic base theory assumes that export is the only exogenous element and this makes the marginal ratio $\frac{\Delta E_T}{\Delta E_B}$ equal the average ratio $\frac{E_T}{E_B}$ (see H. W. Richardson [51], p. 20). This assumption of the economic base theory is often criticized as being unrealistic in real world situations when there is bound to be other exogenous elements and hence making the marginal ratio not equal the average ratio. Because of this, the regional multiplier as computed from (7.5) above is criticized as being not useful for multiplier analysis. For a further discussion on this point, see G. C. Archibald [69], pp. 34-35.

$$(7.5) \quad k_E = \frac{\Delta E_T}{\Delta E_B} = \frac{\Delta E_B + \Delta E_{NB}}{\Delta E_B} = 1 + \frac{\Delta E_{NB}}{\Delta E_B}$$

where k_E is the employment multiplier, and ΔE_T , ΔE_B , and ΔE_{NB} represent respectively, the change in total employment, the change in basic employment, and the change in nonbasic employment.⁸

7.2.2 Data Required for the Short-Run Regional Economic Base Model

The basic data required to test the model described in the previous section is employment data. In the present study the employment data used is that published by the *Commonwealth Bureau of Census and Statistics* for the State of Tasmania. At present, employment statistics are available only for "wage and salary earners in civilian employment". Certain types of employment are excluded from such statistics. The excluded items include (among others) employment in agriculture, in private domestic service, and in the

-
8. In equation (7.5), k_E is expressed in terms of the *marginal* nonbasic-basic ratio, $\frac{\Delta E_{NB}}{\Delta E_B}$. Alternatively, k_E can be expressed in terms of the *average* nonbasic-basic ratio as

$$k'_E = 1 + \frac{E_{NB}}{E_B}.$$

This second alternative is used in cases where the data required for the implementation of a REBM is available only for a particular year or for such a small number of years that the marginal nonbasic-basic ratio cannot be reliably estimated. The solution to the problem then is to compute the employment multiplier from the average nonbasic-basic ratio.

defense forces.⁹ The published civilian employment statistics are classified according to sex and main industry groups. Thus separate series for "male", "female", and "total persons" civilian employment are available. In our study, we have used only the series for "male" employment. It can be argued, of course, that the series for "total persons" would equally be satisfactory for our analysis. However, because "total persons" includes both male and female employments, and since male employment itself is already heterogeneous; lumping together part-time and full-time, junior and adult, skilled and unskilled; it seems pointless to bring in more heterogeneity, i.e. male and female, into our analysis as we would if we were to use the "total persons" series. Of course, it is possible to convert female employment into an equivalent "male unit" as is done by the *Commonwealth Bureau* in estimating average earnings, and then to add this equivalent male unit to total male employment to get a series for total employment in equivalent male units. However, considering the ad hoc nature of this method, we have decided against using it. Thus we proceed with the series for civilian male employment in the following analysis.

The published employment statistics are also classified by main industry groups, with total manufacturing employment being sub-divided into sixteen sub-classes. These employment statistics have provided us with a data base to construct our short-run REEM from which we want to compute employment multipliers for Tasmania.

Recall that to implement our short-run REEM, it is necessary to divide industry employment in Tasmania into basic and

9. See the definition of "Wage and Salary Earners in Civilian Employment" in *Employment and Unemployment* (CSCS, Canberra).

nonbasic categories. This division is the most important aspect of the model and the development of a satisfactory method to achieve this has been noted as a most difficult problem.¹⁰ An attempt has been made in this study to divide industry employment into the basic and nonbasic categories by the location quotient method. Location quotients for each industry group are computed.¹¹ These computed values are used to divide industry employment into basic and nonbasic categories, industry group by industry group. Two methods have been used, thus giving two variants of the basic employment figures and hence to two corresponding variants of nonbasic employment. The industry figures are then summed to give total basic and total nonbasic employment for all industry groups in Tasmania.

The location quotient for industry (i) in Tasmania, (LQ_i), is simply a ratio of an industry's share of the Tasmanian total employment relative to the industry's share of the Australian total employment as is shown below:

$$(7.6) \quad LQ_i = \frac{\frac{e_i}{e_t}}{\frac{E_i}{E_t}}$$

where e_i = Tasmanian industry employment,

e_t = Tasmanian total employment,

E_i = Australian industry employment,

E_t = Australian total employment.

10. See Chapter Four, Section 4.3, for a discussion on the direct and indirect methods of measuring the economic base.

11. The classification of industry groups in this study is the same as that used in *Employment and Unemployment*.

Location quotients for all industry groups in Tasmania have been computed for the period 1948-49 to 1970-71, and these figures are presented in Appendix Table A7.1.

In the context of economic base analysis, it is an accepted convention to regard industries with high location quotients (say over two) as basic and those with low location quotients to be local-serving, i.e. nonbasic. Adopting this convention, the figures in Appendix Table A7.1 indicate that of all the eleven industry groups covered, only four are basic. These are: Forestry, Fishing and Trapping; Mining and Quarrying; Building and Construction; and Public Authority (not elsewhere included). Some industry groups have location quotients very close to unity. These include Community and Business Services; Commerce; and Transport and Communication. The remaining groups have location quotients below unity, although in most cases, their location quotients are still close to unity. Hence it can be concluded that most industry groups in Tasmania, excepting four which are basic, have location quotients close to the value of one. These results are interesting in that they differ in some respects from the general results obtained in other empirical regional studies. In the first place, Building and Construction is found to be basic in Tasmania. This is contrary to the belief that building and construction activities are basically local (nonbasic).¹² Secondly, manufacturing activities in Tasmania have location quotients below the value of unity for the whole sample period, and accordingly

12. See, for example, the Hawaii model as discussed in Chapter Three.

they should be interpreted as nonbasic. This result is in contrast to the assumption commonly adopted in regional studies, that manufacturing industry is basic.¹³

One serious weakness in our method of computing the location quotients is that the industry classification is too broad to be useful for identifying basic industries. Accordingly, a finer grouping is adopted to compute the location quotients for the manufacturing industries. Manufacturing industries in Tasmania are now sub-divided into sixteen sub-classes as adopted in *Secondary Industries and Building*.¹⁴ Location quotients for each sub-class of manufacturing industries for the five year period 1961-62 to 1965-66 have been computed and are presented in Appendix Table A7.5. From the figures presented, we can identify five classes of manufacturing in Tasmania which are basic (under the location quotients interpretation).

These are:

- Class 1 (Treatment of Non-Metalliferous Mine & Quarry Products)
- 6 (Textiles and Textile Goods)
- 9 (Food, Drink and Tobacco)
- 10 (Sawmills, Joinery, etc.)
- 12 (Paper, Stationary, Printing, etc.)

Furthermore, other studies identified fourteen basic manufacturing industries in Tasmania using a still finer industry classification.¹⁵

13. See, for example, the Philadelphia model and the Hawaii model in Chapter Three above.

14. *Secondary Industries and Building* (CBCS, Hobart). Further breakdown of industry employment for other industry groups is not possible from the available employment statistics.

15. See R. J. Solomon in J. L. Davies (ed.) [13].

These results illustrate the importance of a fine industry classification scheme to the objective of identifying basic industries by the location-quotient method. They also illustrate the point that figures calculated for total basic and total non-basic employment by the location-quotient method depend on the particular industry classification scheme adopted. Whereas in the previous analysis, the whole manufacturing sector was identified as non-basic (i.e. total basic employment was zero), now some industries in the manufacturing sector are identified as basic and so the total basic employment for manufacturing is no longer zero.

Other weaknesses inherent in our method of computing industry location-quotients remain to be rectified when a better data base becomes available for Tasmania. One weakness is concerned with the grouping of employment in the public sector. In most other studies, employment in the public sector is divided into Federal and State and Local. In our study, this division of government employment cannot be made because the availability of employment statistics is such that most civilian employees in the government sector are allocated to appropriate industry groupings, leaving only those not classified under any of the major industry groups to appear under "Public Authority n.e.i." Thus, employment in the public sector cannot be divided into the Federal and State and Local categories.

The division of public sector employment into the Federal and the State and Local categories is important because

the individual impact of individual variations in these two categories on the Tasmania economy, as evaluated by the economic base analysis, are often different, depending on the specific nature of the type of employment under consideration. In all of the regional studies which we examined earlier (in Chapter Three) federal employment was treated as basic, i.e. exporting, while state and local employment was treated as non-basic, i.e. local-serving. Public sector employment in Tasmania, however, is probably a mixed bag and any generalization in relation to the specific nature of these two categories of employment is bound to be controversial. For example, while it can safely be assumed that Federal employees in the defence forces, in immigration, and in civil aviation are exporting, those in postal, judiciary and similar functions are more nearly local-serving and therefore nonbasic. On the other hand, while it may be assumed that a substantial portion of State and Local employees are engaged in local-serving activities, those in the marketing and harbour authorities, for example, are engaged in more exporting activities and therefore basic. It is therefore difficult to generalize about the specific nature of each of these two categories of public sector employment, and since the available statistics do not permit the division of these categories the result is that the individual impact of their variations on the Tasmanian economy cannot be evaluated.

The location-quotient method has also been used in this study to divide the total employment of each industry into its basic and nonbasic categories. Two variants of the method have been used giving rise to two estimates of nonbasic employment in Tasmania. In the first, the pro-rata method, we calculate the basic portion of an industry's employment as the difference between employment in the Tasmanian industry and the pro-rata Tasmanian share of employment

in the Australian industry, i.e. by

$$(7.7) \quad e_i^B = e_i - \left(\frac{e_t}{E_t} \right) E_i,$$

where e_i^B = basic industry (i) employment in Tasmania,

e_i = Tasmanian industry (i) employment,

E_i = Australian industry (i) employment,

E_t = Australian total employment,

e_t = Tasmanian total employment.

Or, in terms of its location quotient (LQ_i),

$$(7.8) \quad e_i^B = e_i \left(1 - \frac{1}{LQ_i} \right), \quad \text{where } LQ_i \geq 1.$$

Thus, if for a particular year the location quotient for an industry was 1.5, it would be assumed that one-third $\left(1 - \frac{1.0}{1.5} \right)$ of the industry's employment was basic employment. We repeat the process for each industry group and then sum all the basic portions to yield an estimate of total basic employment in Tasmania. The rest of Tasmanian employment is assigned to the nonbasic category.

We have also used a second, "all-or-nothing", method to derive total basic and total nonbasic employment. In this second method, we assign the whole of an industry's employment either to the basic or to the nonbasic portion depending on the value of the industry's location quotient when compared to some critical value. A location quotient above 1.0 in value is usually viewed as evidence that the industry in question is producing for export outside the region. This test is only a rough guide, and there are many

difficulties in its use.¹⁶ For instance, variations in taste and in capital-labour ratios from region to region can produce coefficients above 1.0 even for exclusively local industries, and below 1.0 even for industries with a significant export demand. Thus, to allow for variations in taste, production functions, etc. the critical value was set at 1.2, rather than 1.0.¹⁷ This variation is especially important, because if an industry qualifies at all, its entire employment figure is included in the basic portion.

Both methods have been applied to the Tasmanian data for the period 1948-49 to 1970-71. As for manufacturing, total employment is further sub-divided into sixteen sub-classes for the five-year period 1961-62 to 1965-66. Basic and nonbasic employment for each sub-class are computed for each year and a five-year average nonbasic-basic ratio is used to divide total manufacturing employment for the whole sample period.¹⁸ In these calculations, one big data problem occurred and must be mentioned here. As is apparent in Appendix Table A7.2, there is a distinct discontinuity in the industrial employment series used, occurring at the year 1960-61. This discontinuity was due to the regrouping of the industrial sectors by the CBCS so that industries like

16. See W. Isard. *Ibid.*, p. 123.

17. A critical value above 1.0, as well as a priori judgments, were also used in other regional base study. See, for example, G.H. Hildebrand and A. Mace Jr., *Ibid.*, pp. 241-49.

18. Location quotients used in the derivation of this five-year average nonbasic-basic ratio were presented in Appendix Table A7.5

Electricity, Gas and Water; and Amusements, Hotels etc.; did not appear until after 1960-61. Before this time, employment in these two industries were included in other industry groups. Thus, location quotients for these two industries cannot be calculated for the period before 1960-61. Such a regrouping will also affect the location quotients for other industries as well as is obvious from Table A7.2 and as we have said earlier on (p.192) that the total basic and total non-basic figures calculated by the location quotients method depend on the industry classification scheme adopted; this reclassification of Tasmanian industries will affect the results of our calculations. This point must be borne in mind when we interpret results of Table 7.1 below.

Basic and nonbasic employments for each industry group are presented in Appendix Table A7.2. It can be seen that the two methods give quite different estimates of basic and nonbasic employment for Tasmania. Furthermore, the all-or-nothing method gives higher estimates of basic employment than the pro-rata method throughout the whole sample period.

7.2.3 Test of the Short-Run Regional Economic Base Model

To test the model formulated in Section 7.2.1 for Tasmania the equation

$$(7.9) \quad \text{ENB} = \frac{a}{1-b} + \frac{b}{1-b} \text{EB},$$

was fitted by ordinary least squares using the annual data for ENB and EB derived in the previous section. The equation was estimated with variables both in absolute-value form and in first-difference form. The estimation results are summarized in Table 7.1 below. Equations (7.10b) and (7.11b) in this table have been estimated from the "pro-rata" series for EB and ENB and equations

Table 7.1

Estimations of Short-Run REBM^(a)

A. *Absolute-Value*

$$(7.10a) \quad \text{ENB}_1 = \frac{1.1}{(11.9)} - \frac{2.64}{(6.89)} \text{EB}_1 \quad R^2 = .694 \quad \text{DW} = .39$$

$$(7.10b) \quad \text{ENB}_2 = \frac{.24}{(.69)} + \frac{3.01}{(1.0)} \text{EB}_2 \quad R^2 = .046 \quad \text{DW} = .10$$

B. *First-Difference*

$$(7.11a) \quad \Delta \text{ENB}_1 = \frac{15.26}{(9.7)} - \frac{1.15}{(21.8)} \Delta \text{EB}_1 \quad R^2 = .959 \quad \text{DW} = 2.04$$

$$(7.11b) \quad \Delta \text{ENB}_2 = \frac{14.9}{(7.3)} - \frac{.95}{(3.1)} \Delta \text{EB}_2 \quad R^2 = .32 \quad \text{DW} = 2.16$$

Note (a) Figures in parentheses are t-ratios.

(7.10a) and (7.11a) from the "all-or-nothing" series. To distinguish the first two from the second two a subscript 2 is attached to the former and a subscript 1 to the latter.

It will be seen that the subscript 1 equations have a much higher R^2 than the subscript 2 equations and are, therefore, preferred. Of the two subscript 1 equations (7.11a) is preferred to (7.10a) because it has a much higher R^2 , because the estimate of the coefficient of ΔEB_1 is highly significant in (7.11a) being more than 20 times its standard error, and because this equation has a DW value approaching 2 which indicates the absence of positive serial correlation.

It will be seen that in the preferred equation (7.11a), ΔEB_1 has a *negative* coefficient. Thus according to this equation an increase in basic employment will lead to a *decrease* in nonbasic employment. Since this contradicts the economic base hypothesis, we conclude that Tasmanian employment does not support the economic base hypothesis. As a consequence we cannot obtain estimates of the employment multiplier for Tasmania from our short-run REBM. However, as it will be seen in Section 7.3.3 below, we can get some estimates of the *income* multiplier for Tasmania from our estimated long-run REBM.

7.3 Long-Run Regional Growth Analysis

This section outlines and uses a second REBM for Tasmania. The model is still based on economic base theory but is now applied to the study of the long-run phenomenon of regional growth. Several general characteristics of this model should be pointed out before it is formally described. First, it is concerned with income, and

uses personal income as the basic unit of measurement rather than employment as is done in the model of the previous section. And, whereas the previous model includes only export activity in the exogenous (i.e. basic) sector,¹⁹ the long-run REBM which we are to describe includes also property income and transfer payments. These two forms of income are not considered at all if employment is the variable used. Second, the long-run REBM focuses on the demand side of income growth without considering growth in capacity. Although constraints on capacity are important, regional data on capacity are not generally available and a pure demand model is far simpler to implement, therefore, than would be one which also attempts to account for changes in capacity. Third, the long-run REBM classifies as either exogenous or endogenous each income component for which regional data is available. Finally, this model considers only growth in current dollar income. Hence we are assuming that relative growth in the money income of the region is indicative of the relative growth of that region's real income. This assumption is valid when trends in prices differ only slightly from state to state within Australia.

7.3.1 Long-Run Regional Economic Base Model for Tasmania

The model which we are to describe is used to study the growth of personal income in Tasmania. It is one in which it is assumed that the rate of growth of total personal income in Tasmania

19. From now on we will talk in terms of exogenous-endogenous sectors instead of basic-nonbasic sectors as we did in the previous section.

can be predicted by the rate of growth in a certain part of income, specified as "exogenous". Exogenous simply refers to that part of income which comes from "outside" a region, especially the income which the region earns by selling goods and services (including the services of capital) to other regions. Since the largest part of Tasmania's exogenous income comes from other parts of Australia, the model thus recognizes dependence of a State on the rest of the nation as a whole. As we said before, our simple model of growth is based on the economic base theory and as such, it is similar to the model we described previously in Section 7.2.1. However, it differs from the previous model in that it is now used in the study of growth rather than in short-run multiplier analysis. In the present section, it is assumed that income from outside is the key element in the rate of growth of economic activity in a region. The local sector, consisting of the producers of goods for local use (by consumers, investors, or government), is seen as relatively passive - expanding if exogenous income grows, contracting if exogenous income falls. The model can now be described more formally. Consider the following two equations which apply to Tasmania in a given year:

$$(7.12) \quad Y_p = Y_e + P + E$$

$$(7.13) \quad Y_e = a + bY_p$$

where Y_p is personal income; Y_e is endogenous income, made up of wages and salaries and proprietors' income in local industries, dependent only on total personal income; P is the sum of property income and

transfer payments, both considered exogenous; and E is earned income consisting of wages and salaries and proprietors' income in industries, including export industries, for which demand is exogenous.

The reduced form of the above model gives:

$$(7.14) \quad Y_p = \frac{a}{1-b} + \frac{(P+E)}{1-b},$$

$$(7.15) \quad Y_e = \frac{a}{1-b} + \frac{b}{1-b} (P+E).$$

Since the model is used in the study of long-run growth, we will derive the rates of growth of both Y_p and Y_e . These can be derived from equations (7.14) and (7.15). In the continuous variable case, if dotted variables represent time derivatives, the rates of growth on Y_p and Y_e are given by:

$$(7.16) \quad \frac{\dot{Y}_p}{Y_p} = \frac{\dot{A}}{A} \frac{A}{a+A}, \text{ and}$$

$$(7.17) \quad \frac{\dot{Y}_e}{Y_e} = \frac{\dot{A}}{A} \frac{bA}{a+bA},$$

where $A = P + E$, total exogenous income,

$\frac{\dot{Y}_p}{Y_p}$ is the rate of growth in Y_p , and

$\frac{\dot{Y}_e}{Y_e}$ is the rate of growth in Y_e .²⁰

20. The derivation of equation (7.16) is as follows. Differentiate equation (7.14) with respect to time t to get:

$$\dot{Y}_p = \frac{dY_p}{dt} = \left(\frac{1}{1-b} \right) \frac{d(P+E)}{dt} = \left(\frac{1}{1-b} \right) \dot{A},$$

where $A = P + E$, and $\dot{A} = \frac{dA}{dt}$.

Since $Y_p = \frac{a+A}{1-b}$ from (7.14), therefore

$$\begin{aligned} \frac{\dot{Y}_p}{Y_p} &= \left(\frac{1}{1-b} \right) \dot{A} \cdot \frac{1}{Y_p} = \left(\frac{\dot{A}}{1-b} \right) \cdot \frac{(1-b)}{a+A} \\ &= \left(\frac{\dot{A}}{A} \right) \cdot \frac{A}{a+A} \text{ as given in (7.16) above.} \end{aligned}$$

Equation (7.17) for $\frac{\dot{Y}_e}{Y_e}$ can be derived in a similar way.

From equations (7.16) and (7.17) it can be seen that the rates of growth in Y_p and Y_e depend on the values of A and of the parameters a and b . Thus the signs and values of the parameters a and b have important implications for the rates of growth in Y_p and Y_e . The value of b is to be restricted in our long-run REBM to be positive and less than one. This follows from the consideration that equation (7.13) above is similar in form to the conventional Keynesian consumption function. The only difference is that equation (7.13) is considered as the sum of three functions for consumption, induced investment, and imports instead of being treated as a consumption function, and for this reason b is called the marginal propensity to consume locally-produced goods. As for a , if a is zero, both Y_p and Y_e grow at the same rate as exogenous income A . If a is positive and if \dot{Y} is positive, both Y_p and Y_e grow more slowly than A ; if a is negative, Y_p and Y_e grow faster than the exogenous sector. Thus, from our long-run REBM, we can make the deduction that the growth of a region can be relatively rapid if exogenous income is growing rapidly and/or if a is negative and large in absolute value.

7.3.2 Data Required for Long-Run Regional Economic Base Model

Australian regional income statistics are designed to reveal personal income, rather than a "gross regional product" or "regional income at factor cost". Although the latter two types of income are often preferred as measures of economic activity for a region, they are not published for Tasmania and hence they need to be estimated. As discussed in Chapter Five, estimation procedures for these two

types of income are very heavily loaded with assumptions and this affects the reliability of these estimates. Hence, personal income is the variable our long-run REBM will attempt to explain.

The *Commonwealth Bureau of Census and Statistics* issues personal income totals for each year, and subtotals for these components:

- Wages, salaries and supplements
- Income of farm unincorporated enterprises
- Income of other unincorporated enterprises
- Income from dwelling rent
- Cash benefits from general government
- All other income.²¹

To implement the model described in Section 7.3.1 above, each of these components of income is designated either exogenous or endogenous. As mentioned earlier, exogenous income in this study refers to that part of income which comes from outside the region. It includes property income and transfer payments (P), and wages and salaries and proprietors' income (i.e. earned income) from export industries (E). What remains from the personal income total is endogenous income. As we said before, this division is the most important aspect of the model. This division has been made by the use of both the "assumption" method and the "location-quotient" method.²² With the exception of wages, salaries and supplements,

21. See Table No. 66 in *Australian National Accounts* (CBCS, Canberra, 1970-71).

22. For a discussion on these two methods of measuring the economic base, see Chapter Four, Section 4.3 above, under the indirect methods.

all components of personal income were classified by assumption either as exogenous or endogenous. The assumption we adopted was that exogenous income includes income of farm unincorporated enterprises, cash benefits from general government, and all other income. The last two components of personal income consist of transfer payments and property income. Transfer payments to Tasmanian residents depend both on the rates which are determined by the Federal Government as well as on the number of pensioners living in Tasmania. Property income received by the Tasmanian residents is, however, the results of their investment decisions in other parts of the country and is therefore exogenous. Farm income is an earned-income component which has been designated by assumption exogenous. This treatment of farm income is often justified by the consideration that farm income has fluctuated so much that it is best considered independent of total personal income, i.e. exogenous. The remaining components of personal income (with the exception of wages, salaries and supplements) were designated by assumption endogenous. These components are non-farm proprietors' income and income from dwelling rent. These components can reasonably be assumed to be dependent on developments of one sort or another within the State of Tasmania and hence they are treated as endogenous.

The division of the wage-income component (i.e. wages, salaries and supplements) of personal income was made by the location-quotient method. This required the subdivision of total wages, salaries and supplements for Tasmania into industry components, and the calculation of the location quotient for each industry. At present, no industry distribution of the series "Wages, salaries and supplements" is being published. However, in response to our request, the *Commonwealth Bureau* supplied us with such a distribution for the State of Tasmania for the year 1964-65. Because there was no alternative,

we decided to use this industry distribution for all industries other than manufacturing to divide total wages, salaries and supplements in Tasmania into its industrial components for the whole sample period 1948-49 to 1970-71. We then applied to the total wages, salaries and supplements of each industry its respective location quotient which we computed earlier on the basis of employment so as to separate the exogenous and the endogenous components. In this connection, both the pro-rata method and the all-or-nothing method used in Section 7.2.2 for classifying industry employment were used to give two variants of E , the earned-income component of exogenous income. As mentioned before, this gave rise to two corresponding variants of Y_e , endogenous income. As for the *manufacturing* wages and salaries, since series for "actual wages and salaries paid" are published by sixteen sub-classes, a five-year (1963-64 to 1967-68) average ratio of basic to nonbasic wages and salaries paid was computed,²³ and this ratio was then used to divide total manufacturing wages and salaries into the respective basic and nonbasic portions for the whole sample period. Figures for total basic and total nonbasic wages and salaries by industry groups are presented in Appendix Table A7.3. Finally, Appendix Table A7.4 lists all the series used in the construction of the long-run REBM for Tasmania.

23. Same method was used in computing basic and nonbasic manufacturing employment; see p. 195.

7.3.3 Test of the Long-Run Regional Economic Base Model

The long-run REBM was tested with annual data for the period 1948-49 to 1970-71 and with both total and per capita variables. The test employed two different variants of A (exogenous income) and thus two corresponding variants of Y_e (endogenous income) since Y_e is defined as total personal income minus exogenous income. The two variants of A differ according to two definitions of E, income from exports outside the state. They will be identified in this study as E_1 and E_2 . The basic equation

$$(7.18) \quad Y_e = \frac{a}{1-b} + \frac{b}{1-b} A$$

was fitted by ordinary least squares regression and the regression results are summarized in the following table.

Table 7.2

OLS Estimations of (7.18)*

A. Total Variables

$$(7.19a) \quad Y_{e_1} = -89.73 + 1.89 A_1 \quad R^2 = .74 \quad DW = .50$$

(2.3) (7.7)

$$(7.19b) \quad Y_{e_2} = -53.84 + 2.73 A_2 \quad R^2 = .96 \quad DW = .94$$

(4.1) (23.4)

B. Per Capita Variables

$$(7.20a) \quad y_{e_1} = -.24 + 1.83 a_1 \quad R^2 = .60 \quad DW = .45$$

(1.7) (5.66)

$$(7.20b) \quad y_{e_2} = -.18 + 2.8 a_2 \quad R^2 = .946 \quad DW = 1.14$$

(3.9) (19.2)

* Figures in parentheses are t-ratios. Subscripts 1 and 2 referred to all-or-nothing method and pro-rata method respectively.

The parameter estimates of a and b (denoted as \hat{a} and \hat{b}) can be derived from the above least-squares estimates of $\frac{a}{1-b}$ and $\frac{b}{1-b}$ for each of the two variants of A. They are summarized below:

From equation (7.19a) $\hat{a} = -31.1, \quad \hat{b} = .653$

(7.19b) $\hat{a} = -14.4, \quad \hat{b} = .732$

(7.20a) $\hat{a} = -.085, \quad \hat{b} = .647$

(7.20b) $\hat{a} = -.047, \quad \hat{b} = .737.$

The primary conclusion is that in general both definitions of exogenous income produced very good fits, although variant 2 (i.e. estimates derived by pro-rata method) was slightly superior in both total and per capita variable forms.

The estimates of b are highly significant, often twenty times greater than their standard errors for variant 2. However, these results must be interpreted carefully since the Durbin-Watson test shows significant (at both 5% and 1% levels) positive auto-correlation in the residuals from the equation.²⁴ This means that the standard errors are frequently underestimated. The general relationship, however, is obviously significant.

The use of per capita rather than total variables has the effect of reducing the closeness of fit slightly. This is because the division of both dependent and independent variables by population has removed some of the common trends which exist between

24. Critical "lower-limits" for $n = 23$, and $k = 1$ at 5% and at 1% levels are respectively $(d_L) = 1.29$ and 1.05 . Hence computed D-W statistic $d < d_L$. This means that significant positive auto-correlation exists. See J. Johnston [31], *"Econometric Methods"*, p. 192.

exogenous and endogenous incomes. In spite of the smaller R^2 values, the per capita form is preferred in this study since it removes the effect of population size on endogenous incomes.²⁵

As explained earlier,²⁶ the parameter b is the marginal propensity to consume locally, and its value shows the portion of any increase in total personal income which is spent on locally-produced goods and services. The estimated values of b range from .65 for variant 1 of A to .74 for variant 2. Accordingly, from the evidence presented, it can be concluded that for every extra dollar increase in total personal income, about 65 cents to 74 cents are spent on goods and services produced in Tasmania. The rest will go into imports, savings and taxes.

All the estimated values of a are negative. This reflects the fact that endogenous income in Tasmania is growing faster than exogenous income, and that the ratio of endogenous to total personal income is rising as the total is rising over time.²⁷ A negative value for a is taken to mean that "the multiplier response at the margin is greater than the accumulated responses of the past which determined the value of Y_e/Y_p at the beginning of the period."²⁸

25. For a further discussion on this point, see R. E. Bolton [2].

26. See Section 7.3.1, page 202.

27. See page 202 above for an explanation of these statements about growth.

28. See R. E. Bolton, *Ibid.*, pg. 28. Bolton also gave three possible factors which will give rise to a high marginal response, and a suitable combination of these factors may lead to a negative value of a for a particular region.

We can also separate the influence on endogenous income (Y_e) of the "property income" part of exogenous income (P) from the wage income part (E) by fitting the following equation for the same sample period 1948-49 to 1970-71 as:

$$(7.21) \quad Y_e = a' + b'P + e'E$$

The results obtained are presented in the following table:

Table 7.3

OLS Estimations of (7.21)

A. Total Variables

$$(7.22a) \quad Y_{e_1} = 33.95 + 4.67 P - .54 E_1 \quad R^2 = .97 \quad DW = .789$$

(2.2) (20.9) (2.7)

$$(7.22b) \quad Y_{e_2} = 8.81 + 4.09 P + .66 E_2 \quad R^2 = .985 \quad DW = .771$$

(.628) (16.07) (1.74)

B. Per Capita Variables

$$(7.23a) \quad y_{e_1} = .10 + 4.37 p - .42 e_1 \quad R^2 = .954 \quad DW = .72$$

(1.8) (18.5) (1.96)

$$(7.23b) \quad y_{e_2} = 1.91 + 3.83 p + 1.0 e_2 \quad R^2 = .978 \quad DW = .914$$

(.04) (18.0) (2.8)

The tests of significance on the regression coefficients show that the explanatory power of P alone is considerably greater than that of E alone.²⁹ Also, the estimates of a' are now positive as compared with

29. This can be seen better using the partial correlation coefficients or the partial F-test. See Chapter Six, Section 6.3 on the use of partial F-values in stepwise regression.

the negative values obtained for a when fitting equation (7.18). The poor explanatory power of E (as compared to P) has been explained by Bolton as stemming "... mostly from the fact that it [E] typically declines greatly in recession, while P does not; this highly stabilizing effect of P provides a floor for Y_e , thus P and Y_e are more closely related than E and Y_e ."³⁰

The estimated equations (7.19b) and (7.20b) can be used to calculate the income multiplier for Tasmania. As discussed previously,³¹ and using the notations of the present section, the income multiplier for Tasmania can be calculated from

$$(7.24) \quad k = 1 + \frac{\Delta A}{\Delta Y_e},$$

where k is the income multiplier. Estimated values of k range from 3.73 (from equation (7.19b)) to 3.8 (from equation (7.20b)). These values are consistent with that obtained in other regional studies.³²

30. See R. E. Bolton, *Ibid.*, p. 52.

31. See p. 186 of this chapter.

32. Values of k are usually found around 3 and 4. However, these values of k depend on a lot of factors, like the size of region, industry mix and so on.

CHAPTER EIGHT
FORECASTING PERFORMANCE OF THE
TASMANIAN REGIONAL EMPIRICAL MODEL

8.1 Introduction

As mentioned in Chapter Six, the main reason for the development of our REMM was to provide a means of forecasting three Tasmanian aggregates and this being so, we want to evaluate its forecasting performance. In this chapter we shall attempt to do this by comparing forecasts made by our REMM with forecasts made by so-called "intrinsic" models.¹ Intrinsic models are simple, extrapolative models in which information contained in past observations on the time series in question is exploited to generate forecasts for the series, i.e. to extrapolate the past. They differ from econometric models, such as our REMM, in that they generate forecasts for a particular variable on the basis of an analysis of the past record of that variable alone, whereas econometric models forecast one variable, the dependent variable, by evaluating the future values of other variables, the independent variables, via a relationship which exists between the dependent variable and the independent variables. The simplest intrinsic model would be

$$(8.1) \quad \hat{X}_{t+1} = X_t,$$

where \hat{X} stands for the forecast value of the variable X . This model forecasts that the value of X for the next time period will be the

1. See W.A. Spivey and W.E. Wecker [134].

same as for the current period. The intrinsic models developed in this chapter are somewhat more complicated. Specifically, two intrinsic models have been developed - one following the Box-Jenkins approach to time series analysis and one based on Brown's exponential smoothing technique. We shall refer to the Box-Jenkins model as IM_1 and the Brown model as IM_2 . The development of IM_1 is discussed in Section 8.2, and the development of IM_2 in Section 8.3. Then in Section 8.4, the forecast results of our REMM are compared with the results of IM_1 and IM_2 for the five-year forecasting period 1967-68 to 1971-72.

Before we move on to Section 8.2, two points related to the evaluation procedure we propose to adopt for comparing the forecasting performances of our three models should be mentioned. The first is the distinction between ex post and ex ante forecasts. In ex ante forecasts the true (recorded) values of the independent variables are not known at the time the forecast is made and must be estimated, whereas ex post forecasts use the recorded values of the independent variables to calculate the forecast values of the dependent variable. Also, ex post forecasts may be obtained either for the whole or part of the sample period or for time periods beyond the sample period for which the values of the independent variables are known. The forecasts made in this chapter are ex post forecasts for part of the sample period, i.e. our models were estimated for the whole sample period 1948-49 to 1971-72 and were then used to generate forecasts for the last five-year period 1967-68 to 1971-72.

The second point connected with the evaluation of the forecasting performance of our models relates to the criterion used for determining forecast accuracy. In this study, the Theil U statistic is used for this purpose. This is discussed in Section 8.4.

8.2 IM₁: Box-Jenkins Method²

This section is devoted to the development of IM₁ by the Box-Jenkins method. The Box-Jenkins method is an approach to time series analysis which has proved useful in many types of situation in which it is required to build a model for a discrete time series. In this section we attempt to develop Box-Jenkins models for forecasting three Tasmanian economic aggregates: gross state product GSP, total personal income TPI and total employment TEMP. Since we are dealing in this study with *annual* data, we will not be troubled by the seasonal-forecasting problem as would be the case if we were using monthly or quarterly data. Accordingly we shall confine our attention to class of non-seasonal Box-Jenkins models known as the ARIMA class. The best way to introduce the ARIMA model is by way of a special case known as the ARMA model. A time series is said to be generated by a mixed autoregressive moving average model of order p,q (ARMA (p,q) model) if

$$(8.2) \quad X_t = \phi_1 X_{t-1} + \phi_2 X_{t-2} + \dots + \phi_p X_{t-p} + a_t - \theta_1 a_{t-1} - \dots - \theta_q a_{t-q}$$

where the ϕ s and the θ s are constants satisfying the "stationarity" condition and the "invertibility" condition, respectively, and where

2. G.E.P. Box and G.M. Jenkins [6]. In our discussion we will be concerned only with the practical steps involved in a Box-Jenkins analysis; the theoretical basis of the analysis is well covered in Box and Jenkins, *op.cit.*

the a 's are members of $\{a_t\}$, a stochastic (white-noise) process with $E(a_t) = 0$; $\text{var}(a_t) = \sigma_a^2$ for all t (σ_a^2 a finite constant) and $\text{cov}(a_s, a_t) = 0$ for all s and t such that $s \neq t$.

Representation (8.2) can be simplified by the introduction of the backward-shift operator B . Let B be the backward-shift operator so that $BX_t = X_{t-1}$. Then if

$$\phi_p(B) = \sum_{j=0}^p \phi_j B^j \quad \text{and} \quad \theta_q(B) = \sum_{j=0}^q \theta_j B^j,$$

(8.2) can be written in the form:

$$(8.3) \quad \phi_p(B)X_t = \theta_q(B) a_t,$$

It is to be noted that the ARMA model provides a representation for a "stationary" time series only.³ For some economic time series it is clearly unrealistic to assume, a priori,

-
3. In this type of time series analysis, the concept of "stationarity" of a time series is fundamental. A time series may either be "strictly" stationary or "covariance" stationary. If we define a time series narrowly as a family of real-valued random variables $\{X_t\}$, then a *strictly stationary* time series is defined to be any time series possessing the property that every finite collection of random variables $\{X(t_1), X(t_2) \dots X(t_n)\}$ has the same joint distribution function as $\{X(t_1 + h), \dots, X(t_n + h)\}$ for any integer h . A consequence of this definition is that a time series is strictly stationary if and only if the expected value of X_t is independent of t and the covariance of X_{t_j} and X_{t_k} ($\gamma_X(t_j, t_k)$) is a function only of the difference $t_j - t_k$. (See J. L. Doob [14], for a more detailed discussion.) In applied time series analysis, the assumption of strict-stationarity is often too restrictive and hence another concept, covariance (or weak) stationarity, is found more useful. A *covariance stationary* time series is defined to be any time series such that the expected value of X_t is independent of t and the covariance of X_t and X_{t+h} is a finite-valued function only of h . The ARMA model provides a representation for a covariance-stationary time series.

that the assumption of stationarity holds. Box and Jenkins have suggested a generalized form of (8.3) for the representation of a broad class of nonstationary time series which they called "homogeneously nonstationary" time series. From their observation that a homogeneously nonstationary time series when successively differenced in the appropriate way can result in a stationary time series, Box and Jenkins suggest the following generalized form for (8.3) which can represent both stationary and nonstationary time series:

$$(8.4) \quad \phi_p(B)(1-B)^d X_t = \theta_q(B) a_t,$$

where d denotes the number of differencings required to transform a given homogeneously nonstationary time series into a stationary series. Representation (8.4) is called an integrated autoregressive moving average process of order p, d, q ARIMA (p, d, q).

The Box-Jenkins approach to time series analysis is concerned with fitting an ARIMA (p, d, q) model to a given time series. But as can be seen from (8.4) the general ARIMA model contains too many parameters. The problem, therefore, is to find a model within the ARIMA class, with as few parameters as possible, which adequately describes the series. In other words, the Box-Jenkins approach to time series analysis requires the determination of suitable values for the parameters p, d , and q . Box and Jenkins suggest that the proper way to find suitable values for the parameters p, d, q is through three main iterative stages which they call, respectively, Model Identification, Estimation, and Diagnostic Checking. We will

examine each of these three stages in turn in relation to the development of IM_1 .

8.2.1 Model Identification

The first stage of the Box-Jenkins procedure is to determine "reasonable" values for the parameters p , d , and q of the general ARIMA model represented by (8.4). To determine d , the degree of differencing required, the given series $\{X_t\}$ is successively differenced until a stationary series $\{W_t\}$ is obtained. For evidence of stationarity in $\{X_t\}$ and in the differenced series, the sample autocorrelations are examined to see whether they cut out abruptly after a small number of lags.

Series for the three Tasmanian aggregates: GSP, TPI, and TEMP, were employed in this exercise and the sample autocorrelations for each series $\{X_t\}$, $\{(1 - B)X_t\}$, and $\{(1 - B)^2X_t\}$ are given in Table 8.1. Note that the series contain 24, 23, and 22 observations (very small in terms of a Box-Jenkins analysis) respectively. Referring to the figures in Table 8.1, one can see that the general pattern of autocorrelation function for each series $\{X_t\}$ is identical; the values of the sample autocorrelations fall from the first lag till somewhere near lag 8 when the values start to increase but in the negative direction. Even the first-differenced series $\{(1 - B)X_t\}$ contains some degree of non-stationarity since, for instance, for $(1 - B) \text{ GSP}_t$ the first five values are all positive, whilst the rest (except lag 7) are negative. The second-differenced series $\{(1 - B)^2X_t\}$ seems to improve on this by producing alternative positive and negative values for the sample autocorrelations but there are peaks in the

Table 8.1

Sample Autocorrelations of $(1 - B)^d X_t$ for $d = 0, 1$, and 2

Series	Lags	Autocorrelations							
GSP _t	1-7	0.874	0.747	0.626	0.512	0.403	0.288	0.187	
	8-14	0.087	-0.011	-0.112	-0.232	-0.349	-0.495	-0.635	
(1-B) GSP _t	1-7	0.473	0.426	0.225	0.243	0.364	-0.075	0.051	
	8-14	-0.243	-0.121	-0.366	-0.279	-0.482	-0.739	-0.497	
(1-B) ² GSP _t	1-7	-0.630	0.187	-0.031	-0.064	0.233	-0.207	0.204	
	8-14	-0.455	0.412	-0.187	0.280	-0.609	0.429	-0.112	
TPI _t	1-7	0.859	0.728	0.613	0.509	0.414	0.296	0.192	
	8-14	0.089	-0.014	-0.119	-0.247	-0.373	-0.517	-0.647	
(1-B) TPI _t	1-7	0.367	0.480	0.292	0.157	0.294	-0.064	-0.004	
	8-14	-0.339	-0.190	-0.407	-0.367	-0.651	-0.504	-0.519	
(1-B) ² TPI _t	1-7	-0.542	0.211	-0.240	0.104	0.405	-0.468	0.338	
	8-14	-0.536	0.652	-0.465	0.348	-0.305	-0.177	0.448	
TEMP _t	1-7	0.921	0.820	0.710	0.589	0.454	0.311	0.173	
	8-14	0.063	-0.064	-0.177	-0.304	-0.442	-0.605	-0.781	
(1-B) TEMP _t	1-7	0.167	0.246	-0.079	0.063	-0.164	-0.217	-0.209	
	8-14	-0.219	-0.111	-0.023	0.059	-0.250	-0.209	-0.368	
(1-B) ² TEMP _t	1-7	-0.546	0.267	-0.299	0.236	-0.087	0.086	-0.196	
	8-14	0.049	-0.133	0.013	0.229	-0.147	0.070	-0.487	

$\{(1 - B)^2 \text{GSP}\}$ series, for instance, at lags 1, 8, 12 and 13. It can be seen that the values for the sample autocorrelations at these lags exceed twice their standard errors (approximately given by $(\frac{1}{\sqrt{T}}) = \frac{1}{\sqrt{22}} = 0.213$).

From the results presented, it is difficult to conclude that any of the series tested is stationary since no series has sample autocorrelation function which "dies out" after a certain lag. To proceed with our Box-Jenkins analysis, we have decided to adopt $d = 1$ for all the three series under study since this gave the least variance value for all the three series as compared to when using other values for d .

Having determined a reasonable value for d , we next proceed to determine suitable values for p and q . Thus, on the assumption that the first-differenced series $\{(1 - B)X_t\}$ are stationary, we want to find a model within the ARMA class, with as few parameters as possible, which describes the series adequately. Theoretically, this is also done by examining the sample autocorrelations and comparing them with various known theoretical autocorrelation functions. For instance, it can be shown that a first order AR model ($p = 1, q = 0$) possesses the property that its autocorrelation function falls exponentially from the first lag, and that a first order MA model ($p = 0, q = 1$) has an autocorrelation function with a spike at the first lag and zero elsewhere. For a mixed ARMA model, the autocorrelation function will exhibit a combination of these features. Thus by comparing the pattern of the sample autocorrelations with these theoretical autocorrelation functions, one can identify a tentative model to be used for forecasting. However, it is hard to

judge whether any of the above sample ARMA models is appropriate and accordingly from the sample autocorrelations presented in Table 8.1 we have decided to obtain reasonable values for p and q through experimentation. For each of the three series, we tried different pairs of values for p and q : ($p = 1, q = 0$), i.e. a first order AR model; ($p = 1, q = 1$); ($p = 2, q = 0$); ($p = 0, q = 1$); and ($p = 0, q = 2$). For practical reasons, ARMA models of higher orders were not tried. The results of this experimentation are discussed in the next section.

8.2.2 Model Estimation

Having failed, even tentatively, to identify a suitable model for forecasting at the Model Identification stage we will now experiment with different pairs of values for p and q in order to produce what appears to be a suitable model. For each of the three pairs of values of p and q mentioned in the preceding section, we obtained estimates of the ϕ and θ parameters of equation (8.4) by means of the non-linear estimation procedure recommended by Box and Jenkins.⁴ The results are summarized in Table 8.2.⁵

8.2.3 Diagnostic Checking

Having estimated the models we thought worth experimenting with, we arrive at the final stage of the Box-Jenkins procedure in which we examine the estimated residuals from the fitted model to see if it is adequate. The white noise series $\{a_t\}$ were generated as part of the estimation procedure and from which we obtained our residual

4. See Box and Jenkins, *Ibid.*, Chap. 7, especially Section 7.2.

5. Although we have tried all the five different pairs of values of p and q mentioned in Section 8.2.1, results for the first three pairs of p and q values are presented only. Experiments involving the remaining two pairs ($p=0, q=1$, and $p=0, q=2$) were unsuccessful since they failed to give convergent estimates for the parameters estimated and hence these results are not presented in Table 8.2.

Table 8.2

Box-Jenkins Parameter Estimates*

Models Tested				Estimates of Parameters				MSR	Q	d.f.
	p	d	q	ϕ_1	ϕ_2	θ_1	θ_2			
A. GSP	1	1	0	.898 (7.31)				316.9	35.37	13
	1	1	1	1.057 (31.8)		0.753 (4.8)		193.2	21.37	12
	2	1	0	.410 (2.7)	.602 (3.15)			193.4	24.53	12
B. TPI	1	1	0	.959 (7.88)				288.3	50.25	13
	1	1	1	1.084 (24.7)		0.672 (3.67)		194.8	24.89	12
	2	1	0	.513 (2.68)	.565 (2.67)			195.9	22.21	12
C. TEMP	1	1	0	.718 (4.84)				3.7	18.13	13
	1	1	1	.994 (132.6)		1.296 (7.02)		1.7	8.69	12

* Figures in parentheses are t-ratios.

$Q = T \sum_{k=1}^m r_k^2$, is a statistic recommended by G.E.P. Box and D. A. Pierce [75], for use in diagnostic checking, with T as the number of observations, m as the degrees of freedom for Q less (p + q) and r_k as the k^{th} autocorrelation coefficient of the residuals.

d.f. denotes the degree of freedom for Q.

series. The most important diagnostic check consists of examining the autocorrelation function of the estimated residuals which are presented in Table 8.3.

The Box-Jenkins procedure involves the transformation of a given time series into a random white noise process.⁵ It follows that if any of the models with which we have experimented is adequate, its residual autocorrelations should conform with the properties of the white noise processes, i.e. should be insignificantly from zero.⁶ On examining Table 8.3, it can be seen that for all the three series we tested, the ARIMA (1, 1, 1) model gives fairly small autocorrelation coefficients, although at some lags, such as at lags 8 and 12 for GSP, the coefficients have an absolute value which is greater than twice their standard error ($\approx \frac{1}{\sqrt{23}} = 0.208$). Looking back into Table 8.2, it can be seen that of all the models tested, the ARIMA (1, 1, 1) model gives the smallest MRS-value for all three series used. Another check we used on the overall adequacy of the ARIMA (1, 1, 1) model involves the use of the Q-statistic which was recommended by Box and Pierce.⁷ The hypothesis being tested here is that if the model is adequate, Q should be approximately distributed as χ^2 with $(m - p - q)$ degrees of freedom, where m is the largest number of lags. The critical value for 12 degrees of freedom at the 5% critical point is 21 and since ARIMA (1, 1, 1) for TPI has a value of Q (≈ 24.89) in excess of this critical value, this model is not

5. See Box and Jenkins, *Ibid.*, Ch. 8.

✓ 6. See above, p. 218.

7. See footnote in Table 8.2 marked with an asterisk.

Table 8.3
Sample Autocorrelation of the Residuals from Fitted Models

Models Used		Lags	Autocorrelations							
A. For GSP										
P <u>d</u> q										
1	1 0	1-7	-0.603	0.201	-0.017	-0.062	0.245	-0.203	0.203	
		8-14	-0.450	0.390	-0.191	0.249	-0.604	0.386	-0.143	
1	1 1	1-7	-0.135	0.170	0.067	0.053	0.224	-0.160	-0.064	
		8-14	-0.485	0.138	-0.166	-0.068	-0.691	0.034	-0.172	
2	1 0	1-7	-0.160	-0.203	-0.014	0.059	0.273	0.075	-0.039	
		8-14	-0.401	0.064	0.384	-0.061	-0.752	0.053	-0.173	
B. For TPI										
P <u>d</u> q										
1	1 0	1-7	-0.521	0.218	-0.228	0.100	0.408	-0.462	0.336	
		8-14	-0.526	0.634	-0.463	0.334	-0.299	-0.195	0.423	
1	1 1	1-7	-0.099	0.088	-0.157	0.194	0.448	-0.309	0.074	
		8-14	-0.383	0.395	-0.246	0.101	-0.389	-0.394	0.144	
2	1 0	1-7	-0.046	-0.228	-0.154	0.275	0.437	-0.219	-0.063	
		8-14	-0.239	0.291	-0.003	0.153	-0.343	-0.453	0.285	

~~2 1 0 8-14 -0.239 0.291 -0.003 0.153 -0.343 -0.453 0.285~~

C. For TEMP

p d q

1 1 0	1-7	-0.489	0.256	-0.287	0.218	-0.101	0.018	-0.197
	8-14	0.004	-0.118	0.027	0.229	-0.163	0.054	-0.456
1 1 1	1-7	0.037	0.160	-0.177	0.040	-0.192	-0.233	-0.219
	8-14	-0.191	-0.066	0.052	0.165	-0.170	-0.085	-0.268

quite suitable for this series. On the other hand, the ARIMA (1, 1, 1) remains adequate for GSP and TEMP.

We will now sum up our Box-Jenkins analysis. It appears from the foregoing discussion that the ARIMA (1, 1, 1) model is likely to be reasonably satisfactory for representing the time series for the three Tasmanian aggregates: gross state product, total personal income and total employment. Accordingly IM_1 will consist of the following three forecasting equations:

$$(8.5) \quad GSP_t^1 = 1.057 GSP_{t-1}^1 + a_t - 0.753 a_{t-1}$$

$$(8.6) \quad TPI_t^1 = 1.084 TPI_{t-1}^1 + a_t - 0.672 a_{t-1}$$

$$(8.7) \quad TEMP_t^1 = 0.994 TEMP_{t-1}^1 + a_t - 1.296 a_{t-1}.$$

Notice that equations (8.5), (8.6), and (8.7) are expressed in first differences and for this reason we have denoted the variables with a superscript 1. These three equations were used to generate forecasts for the five-year period 1967-68 to 1970-71 for each of the three aggregates. The procedure used in this connection will be explained in Section 8.4 and the forecasts themselves presented.

8.3 IM_2 : Exponential Smoothing Method

In this section we will discuss the development of IM_2 by means of the exponential-smoothing or exponentially-weighted-moving-average method proposed by Brown.⁸

8. R. G. Brown [7].

Before we can describe the procedure followed it is necessary to explain the terms single exponential smoothing, double exponential smoothing and triple exponential smoothing.

Single exponential smoothing of a time series is a procedure defined by the following formula:

$$(8.8) \quad S_t(S) = \alpha X_t + (1 - \alpha)S_{t-1}(X),$$

where α is a constant known as the "smoothing constant", satisfying $0 < \alpha < 1$. X_t is the observation for period t , $S_t(X)$ is the "single-smoothed statistic" for period t and $S_{t-1}(X)$ the single-smoothed statistic for the previous period. That is, the single-smoothed statistic for period t is a weighted arithmetic average of the observation for period t and the single-smoothed statistic for period $(t - 1)$. Clearly, given an initial value of the single-smoothed statistic, say $S_0(S)$, a time series for the single-smoothed statistic, paralleling the time series $\{X_t\}$, can be imputed by successive application of (8.8). We shall refer to such a series as the *smoothed data*.

Double exponential smoothing of a time series is a procedure defined by the following:

$$(8.9) \quad S_t^2(X) = \alpha S_t(X) + (1 - \alpha)S_{t-1}^2(X),$$

where $S_t^2(X)$ is the "double-smoothed statistic" for period t , and $S_{t-1}^2(X)$ the double-smoothed statistic for period $(t - 1)$. Thus

double exponential smoothing is exactly the same operation as single exponential smoothing except that the smoothed data takes the place of the time series itself. Given an initial value of the double-smoothed statistic, say $S_0^2(X)$, a time series for the double-smoothed statistic, paralleling the time series $\{X_t\}$ and the smoothed data, can be computed in successive application of (8.9). We shall refer to such a series as the *double-smoothed data*.

Finally, *triple exponential smoothing* of a time series is the procedure defined by:

$$(8.10) \quad S_t^3(X) = \alpha S_t^2(X) + (1 - \alpha) S_{t-1}^3(X),$$

where $S_t^3(X)$ and $S_{t-1}^3(X)$ are, respectively, the "triple-smoothed statistic" for period t and for period $(t - 1)$. Thus, triple exponential smoothing is exactly the same operation as single exponential smoothing except that it is performed on the double-smoothed data instead of the time series itself. Given an initial value of the triple-smoothed statistic, say $S_0^3(X)$, a time series for the triple-smoothed statistic, paralleling the time series, the smoothed data and the double-smoothed data can be computed by successive application of (8.10). Such a series will be referred to as the *triple-smoothed data*.

Returning now to IM_2 the first point to note is that two alternative forms of IM_2 were produced for each of the variables of interest, i.e. GSP, TPI and TEMP. These may be stated in terms of the alternative forecast equations as follows:

$$(8.11) \quad \hat{X}_{t+\tau} = a_t + b_t \tau$$

$$(8.12) \quad \hat{X}_{t+\tau} = a_t + b_t \tau + \frac{1}{2} c_t \tau^2$$

In these expressions, $\hat{X}_{t+\tau}$ is the forecast of the variable (GSP, TPI or TEMP as the case may be) made in period t for a period τ periods ahead (τ is referred to as the "lead time") and a , b and c are constants which have to be estimated. Thus in the first version of IM_2 the forecast equation is a linear function of the lead time while in the second version the forecast equation is a second-degree function of the lead time. Once the constants of these equations have been estimated the resulting numerical equations can be used to produce forecasts, as of period t , for any number of periods ahead.

To estimate the constants a and b in (8.11) for, say, GSP we first constructed the smoothed data and the double-smoothed data from the GSP series. For this purpose we used $\alpha = 0.1$ and initial values $S_0(X)$ and $S_0^2(X)$ derived from:

$$S_0(X) = \hat{a}_0 - \frac{1-\alpha}{\alpha} \hat{b}_0$$

$$S_0^2(X) = \hat{a}_0 - 2 \frac{1-\alpha}{\alpha} \hat{b}_0$$

where \hat{a}_0 and \hat{b}_0 are initial estimates of a and b .⁹ The smoothed data

9. To obtain these initial estimates we fitted a linear trend equation to the GSP series. Of course, if the smoothing operation had begun in 1948-49 we would not have had the necessary data to estimate \hat{a}_0 and \hat{b}_0 in this way and so we have been forced to use some other, possibly less satisfactory method of doing so. This means that the forecasts that we shall derive from IM_2 may be more favourable than can be expected in practice from this model. However, since the same is true of our REMM forecasts (they too are ex post) the comparison between the forecast performances of the two methods should not be affected.

Table 8.4

Smoothed Data and Double-Smoothed Data for GSP, TPI and TEMP

Year	GSP ^(a)			TPI ^(b)			TEMP ^(c)		
	Series	Smoothed Data	Double-Smoothed Data	Series	Smoothed Data	Double-Smoothed Data	Series	Smoothed Data	Double-Smoothed Data
1948-49	86	-144	-381	99	-120	-342	76	53	32
1949-50	106	-119	-355	121	-96	-318	78	56	34
1950-51	147	-92	-328	163	-70	-293	81	58	37
1951-52	166	-66	-302	186	-44	-267	82	60	39
1952-53	186	-41	-275	209	-19	-242	83	63	41
1953-54	222	-15	-249	214	4	-218	85	65	43
1954-55	246	11	-223	235	27	-192	88	67	46
1955-56	280	38	-196	268	51	-168	90	69	48
1956-57	291	64	-170	275	73	-144	90	71	50
1957-58	296	87	-144	283	94	-121	92	73	52
1958-59	300	108	-119	287	113	-98	94	75	55
1959-60	336	131	-94	322	134	-75	97	78	57
1960-61	344	151	-70	337	154	-52	98	80	59
1961-62	364	172	-45	356	174	-30	99	82	61
1962-63	381	193	-21	368	194	-8	100	84	63
1963-64	415	216	3	400	215	14	105	87	66
1964-65	451	239	26	434	237	36	107	89	68
1965-66	473	262	50	457	260	58	115	92	70
1966-67	527	289	74	506	285	80	119	94	72

(a) For GSP, $\hat{a}_0 = 67.83$; $\hat{b}_0 = 26.41$. Hence

$$s_0(x) = \hat{a}_0 - \frac{1-\alpha}{\alpha} \hat{b}_0 = 67.83 - \left(\frac{0.9}{0.1} \right) (26.41) = -169.86$$

$$s_0^2(x) = \hat{a}_0 - 2\left(\frac{1-\alpha}{\alpha} \right) \hat{b}_0 = 67.83 - 2\left(\frac{0.9}{0.1} \right) (26.41) = -407.55$$

(b) For TPI, $\hat{a}_0 = 78.46$; $\hat{b}_0 = 24.76$. Hence

$$s_0(x) = -144.5$$

$$s_0^2(x) = -367.5$$

(c) For TEMP, $\hat{a}_0 = 72.6$; $\hat{b}_0 = 2.4$. Hence

$$s_0(x) = 51.0$$

$$s_0^2(x) = 29.4$$

and the double-smoothed data are shown for each of the three variables in Table 8.4.

Having constructed the smoothed data and the double-smoothed data for GSP we next estimated the a and b in (8.11) as of 1966-67, from: ⁽¹⁰⁾

$$(8.13a) \quad \hat{a}_{66-67} = 2S_{66-67}(X) - S_{66-67}^2(X) = (2 \times 289) - 74 = 504$$

$$(8.13b) \quad \hat{b}_{66-67} = \frac{1}{9}[S_{66-67}(X) - S_{66-67}^2(X)] = \frac{1}{9}[289 - 74] = 23.9$$

Thus our 1966-67 forecast equation for GSP was:

$$\hat{X}_{t+\tau} = 504 + 23.9\tau$$

We next estimated a and b afresh, using the relations corresponding to (8.13a) and (8.13b), for each of the years 1967-68 to 1970-71. In this way we obtained a series of five forecast equations of the form of (8.11) for GSP. These and the corresponding equations for TPI and TEMP are shown in Table 8.5.

To estimate the constants a , b and c in (8.12) for GSP, say, we first constructed the smoothed data, the double-smoothed data and the triple-smoothed data from the actual series. For this purpose we again used $\alpha = 0.1$ and the initial values $S_0(X)$, $S_0^2(X)$ and $S_0^3(X)$ derived from:

10. The theoretical basis of these formulae is the so-called Fundamental Theorem of Exponential Smoothing. See R. G. Brown and R. F. Meyer [78].

Table 8.5

Forecast Equations of Form $\hat{X}_t = a + bt$ for GSP, TPI and TEMP

Year	GSP		TPI		TEMP	
	\hat{a}	\hat{b}	\hat{a}	\hat{b}	\hat{a}	\hat{b}
1966-67	504	23.9	490	22.8	115	2.4
1967-68	532	24.1	515	22.9	119	2.5
1968-69	564	24.5	544	23.2	122	2.5
1969-70	603	25.3	577	23.8	126	2.6
1970-71	644	26.1	618	24.7	129	2.6
1971-72	689	27.1	665	25.9	130	2.4

$$s_0(X) = \hat{a}_0 - \frac{1-\alpha}{\alpha} \hat{b}_0 + \frac{(1-\alpha)(2-\alpha)}{2\alpha^2} \hat{c}_0$$

$$s_0^2(X) = \hat{a}_0 - \frac{2(1-\alpha)}{\alpha} \hat{b}_0 + \frac{(1-\alpha)(3-2\alpha)}{2\alpha^2} \hat{c}_0$$

$$s_0^3(X) = \hat{a}_0 - \frac{3(1-\alpha)}{\alpha} \hat{b}_0 + \frac{3(1-\alpha)(4-3\alpha)}{2\alpha^2} \hat{c}_0$$

where \hat{a}_0 , \hat{b}_0 and \hat{c}_0 are the least squares estimates of a , b and c in a second-degree polynomial equation fitted to the GSP series.

The smoothed-data, the double-smoothed data and the triple-smoothed data are shown for each of the three variables in Table 8.6.

Having constructed the three smoothed series for GSP we next estimated a , b and c in (8.12) as of 1966-67, from:

$$\begin{aligned}
 (8.14a) \quad \hat{a}_{66-67} &= 3s_t(X) - 3s_t^2(X) + s_t^3(X) \\
 &= 3 \times 323 - 3 \times 206 + 153 \\
 &= 504
 \end{aligned}$$

Table 8.6

Smoothed Data, Double-Smoothed Data, and Triple-Smoothed Data for GSP, TPI and TEMP

Year	GSP (a)				TPI (b)				TEMP (c)			
	Series	Smoothed Data	Double-Smoothed Data	Triple-Smoothed Data	Series	Smoothed Data	Double-Smoothed Data	Triple-Smoothed Data	Series	Smoothed Data	Double-Smoothed Data	Triple-Smoothed Data
1948-49	86	91	98	162	99	93	211	346	76	69	72	79
1949-50	106	93	98	156	121	95	199	331	78	70	72	78
1950-51	147	98	99	150	163	101	188	317	81	71	72	78
1951-52	166	105	100	145	186	110	180	303	82	72	72	77
1952-53	186	113	101	140	209	120	174	290	83	73	72	77
1953-54	222	124	103	136	214	129	169	278	85	75	72	76
1954-55	246	136	106	133	235	140	166	268	88	76	72	76
1955-56	280	150	110	130	268	153	164	256	90	77	73	76
1956-57	291	164	115	129	275	166	165	246	90	78	73	75
1957-58	296	178	121	128	283	178	167	238	92	80	74	75
1958-59	300	190	128	128	287	190	170	232	94	81	75	75
1959-60	336	205	136	129	322	204	174	227	97	82	75	75
1960-61	344	218	144	131	337	217	178	222	98	84	76	75
1961-62	364	232	152	133	356	231	183	217	99	85	77	76
1962-63	381	246	162	135	368	245	189	214	100	87	78	76
1963-64	415	262	172	138	400	261	196	223	105	88	79	76
1964-65	451	281	183	142	434	278	205	221	107	90	80	76
1965-66	473	300	194	147	457	296	215	221	115	93	82	77
1966-67	527	323	206	153	506	318	226	222	119	95	83	78

(a) For GSP, $\hat{a}_0 = 124.78$; $\hat{b}_0 = 10.88$; $\hat{c}_0 = 0.675$. Hence

$$s_0(x) = \hat{a}_0 - \left(\frac{1-\alpha}{\alpha}\right) \hat{b}_0 + \frac{(1-\alpha)(2-\alpha)}{2\alpha^2} \hat{c}_0 = 124.78 - \frac{.9}{.1} \times 10.88 + \frac{(.9)(1.9)}{(.02)} (.675) = 91.61$$

$$s_0^2(x) = \hat{a}_0 - \frac{2(1-\alpha)}{\alpha} \hat{b}_0 + \frac{(1-\alpha)(3-2\alpha)}{\alpha^2} \hat{c}_0 = 124.78 - \frac{2(.9)}{.1} \times 10.88 + \frac{(.9)(2.8)}{(.01)} (.675) = 99.04$$

$$s_0^3(x) = \hat{a}_0 - \frac{3(1-\alpha)}{\alpha} \hat{b}_0 + \frac{3(1-\alpha)(4-3\alpha)}{2\alpha^2} \hat{c}_0 = 124.78 - \frac{3(.9)}{.1} \times 10.88 + \frac{3(.9)(3.7)}{(.02)} (.675) = 169$$

(b) For TPI, $\hat{a}_0 = 144.9$; $\hat{b}_0 = 6.6$; $\hat{c}_0 = 0.79$. Hence

$$s_0(x) = 92.2$$

$$s_0^2(x) = 225.1$$

$$s_0^3(x) = 360.7$$

(c) For TEMP, $\hat{a}_0 = 77.7$; $\hat{b}_0 = 1.03$; $\hat{c}_0 = .06$. Hence

$$s_0(x) = 68.94$$

$$s_0^2(x) = 72.28$$

$$s_0^3(x) = 79.9$$

$$\begin{aligned}
 (8.14b) \quad \hat{b}_{66-67} &= \left[\frac{\alpha}{2(1-\alpha)^2} \right] [(6-5\alpha)s_t(X) - 2(5-4\alpha)s_t^2(X) \\
 &\quad + (4-3\alpha)s_t^3(X)] \\
 &= \left[\frac{.1}{2(.9)^2} \right] [5.5 \times 323 - 2(4.6)206 + 3.7 \times 153] \\
 &= 27.6
 \end{aligned}$$

$$\begin{aligned}
 (8.14c) \quad \hat{c}_{66-67} &= \left[\frac{\alpha^2}{(1-\alpha)^2} \right] [s_t(X) - 2s_t^2(X) + s_t^3(X)] \\
 &= \left[\frac{(.1)^2}{.9^2} \right] [323 - 2 \times 206 + 153] \\
 &= 0.8
 \end{aligned}$$

Thus our "version two" forecasting equation for GSP as of 1966-67 was:

$$\hat{x}_{t+\tau} = 504 + 27.6\tau + \frac{1}{2} 0.8\tau^2$$

We next estimated a , b and c afresh, using the relations corresponding to (8.14a), (8.14b) and (8.14c) for each of the years 1967-68 to 1970-71, thus obtaining a series of five forecasting equations of the form of (8.12) for GSP. These and the corresponding equation for TPI and TEMP are shown in Table 8.7.

The forecast equations set out in Table 8.5 and Table 8.7 were used to generate forecasts for the five-year period 1967-68 to 1970-71 for each of the three aggregates, GSP, TPI and TEMP. These will be presented and discussed in Section 8.4.

Table 8.7

Forecast Equations of Form $\hat{X}_t = a + b\tau + \frac{1}{2}c\tau^2$ for GSP, TPI and TEMP

Year	GSP			TPI			TEMP		
	\hat{a}	\hat{b}	\hat{c}	\hat{a}	\hat{b}	\hat{c}	\hat{a}	\hat{b}	\hat{c}
1966-67	504	27.6	.80	498	30.4	1.18	114	2.9	.086
1967-68	536	29.2	.81	526	30.7	1.05	120	4.0	.093
1968-69	574	30.5	.85	561	32.3	1.05	123	3.8	.110
1969-70	618	32.4	.88	604	34.5	1.09	128	3.8	.110
1970-71	642	32.7	.85	651	37.0	1.13	129	3.7	.093
1971-72	700	35.3	.93	708	39.5	1.19	136	4.3	.123

8.4 Comparing Forecasting Performance

In this section, we will compare the forecasting results from our REMM (from Chapter Six) with those produced by the two intrinsic models developed in the preceding section. We will firstly compute one-step-ahead forecasts from each model for the five-year period 1967-68 to 1971-72. Then, secondly, we will employ Theil's U statistic to compare their accuracy.

8.4.1 Forecasts from Regional Empirical Model

In Chapter Six above, we developed the following set of forecasting equations:

$$GSP_t = 20.7 + 0.0443 \text{ MGFFRD}_t + 0.507 \text{ GSP}_{t-1}$$

$$TPI_t = 8.97 + 0.035 \text{ PCONSP}_t$$

$$\text{TEMP}_t = 4.6 + 0.00936 \text{ AUSEMP}_t + 0.662 \text{ TEMP}_{t-1}$$

These three equations are now used to compute forecasts for the forecasting period 1967-68 to 1971-72. The results are summarized in Table 8.8.

Table 8.8

Forecasts from REMM for Period 1967-68 to 1971-72*

Year	GSP	ΔGSP	GSP	ΔGSP	TPI	ΔTPI	TPI	ΔTPI	TEMP	$\Delta TEMP$	TEMP	$\Delta TEMP$
1967-68	559	38	547	53	534	41	524	49	121	3	122	3
1968-69	597	56	600	62	575	53	573	56	124	4	125	3
1969-70	653	60	662	55	628	61	629	66	128	3	128	2
1970-71	713	64	717	58	689	66	695	75	131	2	130	0
1971-72	777		775		755		770		133		130	

* \hat{GSP} , $\Delta \hat{GSP}$, GSP , ΔGSP represent respectively the forecast value, the forecast change, the actual value and the actual change of GSP. Similar notations are employed for TPI and TEMP.

8.4.2 Forecasts from IM_1

The forecasting equations developed for IM_1 were:

$$GSP_t = 1.057 GSP_{t-1} + a_t - 0.753 a_{t-1}$$

$$TPI_t = 1.084 TPI_{t-1} + a_t - 0.672 a_{t-1}$$

$$TEMP_t = 0.994 TEMP_{t-1} + a_t - 1.296 a_{t-1}$$

Thus, these forecasting equations are of the general form:

$$Z_t = \beta_0 Z_{t-1} + a_t - \beta_1 a_{t-1},$$

or
$$Z_{t+1} = \beta_0 Z_t + a_{t+1} - \beta_1 a_t.$$

The one-step-ahead forecast, written as $\hat{Z}_t(1)$ is assumed to be given by the conditional expectation $E(Z_{t+1}/H_t)$ where H_t represents the history of the series $\{Z_t\}$ up to time t .

Taking the conditional expectation, we have, assuming that the expectation of a_{t+1} is zero:

$$\hat{Z}_t(1) = \beta_0 Z_t - \beta_1 a_t.$$

For an example, the one-step-ahead forecast for GSP made at 1966-67 is given by:

$$\hat{GSP}_{1966-67} = 1.057 GSP_{1966-67} - 0.753 a_{1966-67}$$

$$\begin{aligned} \text{i.e. } \hat{GSP}(1)_{1966-67} &= 1.057 \times 527 - 0.753 \times 23.95 \\ &= 540 \end{aligned}$$

Other forecasts for the three aggregates for the five-year period are similarly calculated and are presented in Table 8.9.

Table 8.9

Forecasts from IM_1 for Period 1967-68 to 1971-72

Year	GSP	ΔGSP	TPI	ΔTPI	TEMP	$\Delta TEMP$
1967-68	547	17	560	-7	119	3
1968-69	564	83	553	78	122	3
1969-70	647	70	631	58	125	3
1970-71	717	44	689	73	128	1
1971-72	761		762		129	

8.4.3 Forecasts from IM_2

Two forecasting equations were developed for IM_2 and they were of the forms:

$$(8.15a) \quad \hat{X}_{t+\tau} = a + b\tau,$$

$$(8.15b) \quad \hat{X}_{t+\tau} = a + b\tau + \frac{1}{2}c\tau^2$$

Estimates of a and b for (8.15a) and a , b and c for (8.15b) for each of the years 1967-68 to 1970-71 were extracted from Table 8.5 and Table 8.7 respectively presented in Section 8.3 above.

Two sets of forecasts were generated from equations (8.15a) and (8.15b) for the period 1967-68 to 1970-71 and they are presented in Table 8.10.

Table 8.10

Forecasts from IM_2 for Period 1967-68 to 1971-72

Year	(a)						(b)					
	GSP	ΔGSP	TPI	ΔTPI	TEMP	ΔTEMP	GSP	ΔGSP	TPI	ΔTPI	TEMP	ΔTEMP
1967-68	556	33	538	29	122	3	565	40	557	37	124	3
1968-69	589	39	567	33	125	4	605	46	594	45	127	5
1969-70	628	42	600	43	129	3	651	24	639	50	132	1
1970-71	670	46	643	48	132	0	675	61	689	58	133	7
1971-72	716		691		132		736		747		140	

(a) Forecasts generated from equation $\hat{X}_{t+\tau} = a + b\tau$,
 $t = 1$

(b) Forecasts generated from equation $\hat{X}_{t+\tau} = a + b\tau + \frac{1}{2}c\tau^2$,
 $t = 1$

8.4.4 Forecast Evaluation

We will now compare the forecast accuracy of the three models (REMM, IM_1 and IM_2) by the U statistic originally proposed by Theil.¹¹ The U statistic is defined as:

$$(8.16) \quad U = \sqrt{\frac{\frac{1}{n} \sum (P_1 - A_1)^2}{\frac{1}{n} \sum P_1^2 + \frac{1}{n} \sum A_1^2}}$$

where P_1 and A_1 are the forecast and actual values respectively, and n is the number of periods being compared.

The value of U must lie between zero and one. $U = 0$ means that all forecasts are perfect, and $U = 1$ that all forecasts are incorrect. Thus, according to this interpretation the model which gives the least value to the U statistic is preferred.

Both levels and changes were used to compute the U statistic for GSP, TPI and TEMP and the results are presented in Table 8.11. From figures presented in Table 8.11, it can be seen that for all the three series used, the values of the computed U statistic from the REMM are smallest in all cases when the forecast and actual levels were used and, with the only exception of the TEMP series, they were also the smallest when forecast and actual changes were used. From these results we conclude that the REMM for Tasmania performed better than the two intrinsic models when used in forecasting.

11. See H. Theil [57].

Table 8.11

Comparison of Forecast Results from REMM, IM_1 and IM_2 for the Period
1967-68 to 1971-72

<u>Series Used</u>	<u>Model</u>	(a)		(b)	
		U_1	U'_1	U_2	U'_2
GSP	REMM	.0091		.0797	
	IM_1	.0135		.0199	
	IM_2	.0289	.0208	.1809	.1831
TPI	REMM	.0066		.05667	
	IM_1	.0147		.7931	
	IM_2	.0357	.0167	.2308	.1290
TEMP	REMM	.0050		.2257	
	IM_1	.0101		.1404	
	IM_2	.0055	.0119	.1344	.5304

(a) U_1 is U computed from forecast and actual levels.

(b) U_2 is computed from forecast and actual changes.

CHAPTER NINECONCLUSION9.1 Summary and Conclusions

The main purpose of this study was to develop regional econometric models for Tasmania. It was realized at an early stage that not every type of existing REM could be developed at present for Tasmania due to such restrictions on the study as the short time span of the project, lack of data, and so on. Because of these restrictions, only the feasible types of REM were considered for further development, and subsequently a REMM and two REBM were constructed for Tasmania.

The first stage of the study comprised the classification of REM and their uses and an attempt to determine which types of REM were suitable for which uses. This was done in Chapter Two. The main conclusions that emerged from Chapter Two were the following. REBM are used mainly in short-run multiplier analyses and therefore have important policy implications, but they are not useful for forecasting nor for planning. REMM are useful for forecasting but are not suitable for either of the other two uses. Both RSAM and RPFM are useful for forecasting and policy analysis but not for planning, with the former type much stronger in policy analysis than the latter type. Finally, RIOM are useful in all three applications; they are particularly strong in planning but less so in forecasting.

A small sample of twelve existing REM was then selected from the literature and a general account of these was given in Chapter Three. This sample of existing REM which was taken to represent

all the types of REM that could conceivably be developed in Tasmania, was classified into the five types distinguished in Chapter Two.

The next step was to select from the possible types of REM that subset which could conceivably be constructed for Tasmania. To this end a feasibility study was undertaken in which the following procedure was adopted. First, a prototype of each type of REM was selected from the sample of REM discussed in Chapter Three and its data requirements determined. Second, these data requirements were compared with the available Tasmanian statistics. Third, a conclusion was made as to whether the construction of a REM of the type in question for Tasmania was feasible at the present time. This feasibility study was presented in Chapter Four and the conclusion that emerged was that, of the five types of REM distinguished in Chapter Two, only the first two (i.e. REBM and REMM) were feasible for Tasmania. The rest of the study was then devoted to the construction of a model of each of these two feasible types. But before this was begun we digressed to prepare a series for Tasmania's Gross State Product. This was the subject of Chapter Five.

Our series for GSP in Tasmania was estimated from the income side. Thus GSP was estimated as the sum of Tasmanian labour income from current production and Tasmanian entrepreneurial income. The former component was obtained by adding the published estimates of wage-income and income of unincorporated enterprises while the latter was estimated by allocating to the State a share of the Australian entrepreneurial income on the basis of the former component.

An attempt to sub-divide total GSP into its industrial components was unsuccessful because of the lack of published information on the industry distribution of the components of Tasmania's labour income from current production, for the sample period 1948-49 to 1971-72. An attempt to obtain constant-price estimates of Tasmanian GSP was also made using the Australian price indices.

We then returned to the main path of the study and proceeded to construct the two feasible types of REM for Tasmania. The construction of a REMM for Tasmania was undertaken in Chapter Six. This consisted of three regression equations, one for each of the three Tasmanian aggregates (gross state product GSP, total personal income TPI and total employment TEMP).

In each of these three equations the independent variables were chosen by stepwise regression procedure from a set of eighteen potentially relevant Australian, and some overseas-sector economic indicators. For GSP, the independent variables chosen were MGFPD and NINCUK (see Table 6.2 in Chapter Six for notation), for TPI, the independent variable chosen was PCONSP, and for TEMP, the independent variables chosen were AUSEMP and EXPORT. The distributed-lag patterns of the chosen independent variables were then studied for each equation by means of two sets of distributed-lag experiments. Set (A) in which Geometrically-Declining Weights were assumed was preferred to set (B) in which Almon Weights were employed and three regression equations from set (A) were finally chosen to comprise our Tasmanian REMM. The empirical work of Chapter Six was feasible only because of the estimations of GSP undertaken in Chapter Five.

The construction of two REBM (one short-run and one long-run) was undertaken in Chapter Seven. Both models were formulated from economic base theory and were estimated for the sample period 1948-49 to 1970-71. The short-run REBM was estimated from Tasmanian employment data with the main objective of producing estimates of the employment multiplier for Tasmania. Such an attempt failed when the estimated model contradicted the economic base hypothesis by producing the wrong (negative) signs for the regression coefficients. Thus no employment multiplier for Tasmania was computed. On the other hand, the long-run REBM was successful in this respect by producing the right (positive) signs for the coefficients and income multipliers ranging from 3.73 to 3.8 were computed. These values were consistent with those obtained in other regional studies. The main reason for constructing the long-run REBM, however, was to study the relationship between the growth of the Tasmanian economy in relation to the growth in its exogenous sector. The main conclusion derived from the estimated long-run REBM was that Tasmania was growing at a faster rate than its exogenous sector in the sample period. Estimates of the marginal propensity to consume locally (i.e. in Tasmania) were also obtained from the long-run REBM, the values found ranging from .65 to .74. Accordingly, it was concluded that for every extra dollar increase in total Tasmanian personal income, about 65 cents to 74 cents were spent on goods and services produced in Tasmania.

In Chapter Eight, the forecasting performance of the REMM presented in Chapter Six was evaluated by comparing forecasts produced from this model for the five-year period, 1967-68 to 1971-72, with

those produced for the same period by two "intrinsic" models (IM_1 and IM_2). The measure of forecast accuracy employed in the evaluation process was Theil's U statistic. The main conclusion that emerged was that the REMM constructed for Tasmania performed better than the two intrinsic models.

9.2 Some Reflections on Regional Model-Building

A great deal can be learned in the process of constructing regional econometric models for Tasmania. Perhaps the most important lesson to be learned is the need for a flexible research strategy. A sophisticated model (e.g. RSAM, RIOM) may produce much useful information about the regional economy under study but the cost and the effort involved in constructing such a model will often be prohibited. On the other hand, a simple model (e.g. REBM, REMM) may not produce a great deal of information but may be the only one which is feasible in terms of data requirement, time requirement and so on. A sensible strategy is to proceed from the simple models to the more sophisticated as the latter become feasible. This seems to have been the strategy adopted by the research team in the University of Hawaii. In their project, a number of econometric models were constructed for Hawaii as part of a wider planning programme. The first model to appear was an economic base model in 1963.¹ Then research designed to produce a set of regional income and product accounts was undertaken and this eventually led to the appearance of a simple RPFM in 1970.² A more comprehensive RSAM is now under way.³

1. See K. Sasaki [130], *Ibid.*

2. See L. C. Chau [10].

3. See M. Norman and R. Russell [44].

In regional model-building, the model finally constructed is often quite different from the one on which work originally started. Among other things, the paucity of regional data is often the factor which determined the final outcome of a model-building process. One thing which is certain, however, is that until better data sources are available, regional econometric models will continue to be simple. Too few regional economic variables have been measured on a regular basis and for time periods of too short a duration to admit to any other possibility.

APPENDIX

DATA TABLES AND STATISTICAL SOURCES

Appendix Table A5.1

Worksheet for Computing Gross State Product by the Income-Approach, 1953-54 to 1969-70 (\$m.)

	1953-54	1954-55	1955-56	1958-59	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
<i>Australian Figures:</i>															
1. Wages, Salaries and Supplements	4512	4937	5409	6211	6977	7516	7741	8170	8886	9932	10699	11674	12696	14046	15763
2. Gross Operating Surplus of Unincorporated Enterprises	2147	2178	2311	2540	2663	2758	2717	2938	3394	3531	3366	3884	3549	4191	4226
3. = (1) + (2)	6659	7115	7720	8751	9640	10274	10458	11108	12280	13463	14065	15558	16245	18237	19989
4. Gross National Product at Factor Cost	8109	8744	9482	11105	12348	13130	13494	14572	16194	17784	18539	20476	21787	24467	27047
5. Entrepreneurial Income = (4) - (3)	1450	1629	1762	2354	2708	2856	3036	3464	3914	4321	4474	4918	5542	6230	7058
<i>Tasmanian Figures:</i>															
6. Wages, Salaries and Supplements	141	150	164	187	207	218	230	236	256	277	302	335	362	389	434
7. Income of Unincorporated Enterprises	54	54	59	58	61	59	62	63	69	78	72	80	67	81	82
8. = (6) + (7)	195	204	223	245	268	277	292	299	325	355	374	415	429	470	516
9. Entrepreneurial Income = $\frac{(8)}{(3)} \times (5)$	43	47	51	66	75	77	84	91	104	114	119	131	146	160	182
10. Gross State Product at Factor Cost = (8) + (9)	238	251	274	311	343	354	376	390	429	469	493	546	575	630	698
11. Proportion of Labour Income from current production to Gross State Product in percentage = $\frac{(8)}{(10)} \times 100$	82%	81%	81.5%	78%	78%	78%	77.5%	76.6%	75.6%	75.6%	76%	76%	75%	74.5%	74%

Appendix Table A5.2

Gross State Product, by Major Industry Groups, at Current Prices (\$m.)

	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66
Primary Production	46.3	45.7	45.8	49.0	58.0	55.0	50.5
Mining and Quarrying	6.4	6.6	6.5	6.4	7.5	15.5	9.3
Manufacturing	100.0	101.4	106.0	112.0	121.0	115.0	141.0
Electricity, Gas and Water Supply	10.7	11.2	12.7	13.7	14.7	41.3	17.2
Building and Construction	26.2	27.5	29.2	30.2	32.8	19.9	42.0
Transport and Communication	27.2	28.5	30.0	30.5	34.2	43.0	40.5
Commerce	51.7	52.7	56.5	57.5	61.0	68.0	69.5
Public Administration (n.e.i.) and Defence	12.5	12.3	13.7	13.4	14.4	46.0	18.2
Community and Business Services (including professional)	24.1	26.3	29.1	30.4	33.3	22.6	41.7
Finance and Property	11.2	12.1	13.1	13.2	13.9	16.1	17.0
All Other Industries	13.6	14.1	15.2	15.3	16.3	14.5	19.8
Ownership of Dwellings	9	8	10	10	11	10	10
Total	339	346	368	382	418	467	477

Appendix Table A5.3

Gross State Product, by Major Industry Groups, at Constant 1959-60 Prices (\$m.)

	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66
Primary Production	46.3	48.0	49.6	57.7	71.8	69.7	55.5
Mining and Quarrying	6.4	7.2	7.3	7.7	9.8	19.8	13.6
Manufacturing	100.0	109.0	113.5	130.0	152.0	158.0	200.0
Electricity, Gas and Water Supply	10.7	11.7	13.6	16.5	19.3	58.5	26.0
Building and Construction	26.2	28.8	29.8	33.2	39.4	26.9	59.0
Transport and Communication	27.2	29.5	30.8	33.4	40.5	54.0	50.7
Commerce	51.7	54.5	60.5	66.4	75.5	90.7	93.0
Public Administration (n.e.i.) and Defence	12.5	12.2	14.3	13.8	15.2	49.5	21.8
Community and Business Services (including professional)	24.1	27.6	31.7	34.4	38.5	27.2	53.7
Finance and Property	11.2	12.5	13.9	14.5	15.9	20.1	22.3
All Other Industries	13.6	14.2	15.3	16.0	18.3	17.0	23.4
Ownership of Dwellings	9.0	8.4	10.9	11.3	12.9	12.3	12.8
Total	339	364	391	435	509	604	632

Appendix Table A5.4

Australian Price Indices, By Major Industry Groups (Base: 1959-60 = 1000)

	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66
Primary Production	1000	1050	1085	1178	1238	1268	1100
Mining and Quarrying	1000	1094	1131	1205	1303	1279	1463
Manufacturing	1000	1075	1072	1168	1256	1377	1424
Electricity, Gas and Water Supply	1000	1050	1069	1206	1311	1417	1512
Building and Construction	1000	1051	1020	1100	1206	1353	1405
Transport and Communication	1000	1038	1028	1095	1185	1256	1255
Commerce	1000	1035	1071	1155	1242	1337	1338
Public Administration (n.e.i.) and Defence	1000	990	1044	1036	1056	1076	1197
Community and Business Services (including professional)	1000	1050	1090	1130	1156	1207	1287
Finance and Property	1000	1036	1067	1096	1141	1251	1309
All Other Industries	1000	1007	1008	1049	1124	1174	1184
Ownership of Dwellings	1000	1047	1093	1125	1178	1228	1275
Total	1000	1050	1066	1142	1218	1304	1320

Appendix Table A5.5

Income Received by Tasmanian Residents from Current Production, by Major Industry Groups (\$m.)

	1959-60	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66
Primary Production	44.5	44.0	44.3	47.0	55.5	52.8	49.0
Mining and Quarrying	4.2	4.3	4.3	4.2	4.4	9.3	5.4
Manufacturing	70.5	72.5	75.5	78.0	83.0	80.1	99.0
Electricity, Gas and Water Supply	4.5	4.7	5.3	5.2	5.5	15.7	6.5
Building and Construction	24.8	26.0	27.4	28.3	30.8	18.5	38.8
Transport and Communication	22.4	23.0	24.3	23.9	26.3	32.5	30.8
Commerce	40.0	41.8	44.3	44.2	46.0	51.0	54.0
Public Administration (n.e.i.) and Defence	12.5	12.3	13.7	13.4	14.4	46.0	18.2
Community and Business Services (including professional)	23.8	26.0	28.8	29.9	32.8	22.2	41.0
Finance and Property	9.2	9.8	10.5	10.7	11.5	13.3	14.0
All Other Industries	12.1	12.5	13.3	13.4	14.3	12.6	17.2
Total	268	277	292	299	325	355	374

Source to Appendix Tables, Chapter Five

Australian Series

1. Wages, Salaries and Supplements from *Australian National Accounts* (CBCS, Canberra)
2. Gross Operating Surplus of Unincorporated Enterprises from *Australian National Accounts* (CBCS, Canberra)
3. Gross National Product at Factor Cost from *Australian National Accounts* (CBCS, Canberra)
4. Australian Price Indices, by Major Industry Groups, from Table 4, "Estimates of Gross Product by Industry", CBCS, Canberra, Ref. No. 7.7, pg. 14.
5. Industry Distributions of Series 1, 2, and 3 from *Australian National Accounts* (CBCS, Canberra)

Tasmanian Series

1. Wages, Salaries and Supplements from *Australian National Accounts* (CBCS, Canberra)
2. Income of Unincorporated Enterprises from *Australian National Accounts* (CBCS, Canberra)
3. Industry Distributions of Wages, Salaries and Supplements and of Income of Unincorporated Enterprises, by Major Industry Groups for 1964-65 from Unpublished Information provided by the Commonwealth Bureau of Census and Statistics, Canberra.

APPENDIX A6.

Data Table

Year	(\$m.) GSP	(\$m.) TPI	(Thous.) TEMP	(Thous.) AUSEMP	(persons) UNEMPL	(\$m.) GDP	(\$m.) MGFPRD	(\$m.) GNFPRD	(tons) METPRD	(lbs.) WOLPRD	(\$m.) ΔSTOCK	(\$m.) PCONSP	(\$m.) GCONSP	(\$m.) INVDWL	(\$m.) INVOTH	(\$m.) INVGOT	PIDUK	(\$m.) NINCUK	(\$m.) EXPORT	(\$m.) IMPORT	(\$m.) AUSPIN
1948-49	86	99	76	2441	1573	4319	1003	3481	992	1057	37	3001	354	145	352	295	64	95	1146	979	3771
1949-50	106	121	78	2554	13057	5093	1125	3976	1055	1142	72	3457	426	190	454	420	69	106	1307	1260	4419
1950-51	147	163	81	2653	604	6767	1399	4935	1011	1118	144	4209	588	272	649	603	71	116	2092	1726	6063
1951-52	166	186	82	2620	8294	7260	1720	6033	949	1080	384	5017	806	345	787	806	69	127	1486	2437	6288
1952-53	186	209	83	2598	25914	8233	1915	6690	1153	1281	-256	5326	929	363	780	794	73	136	1855	1312	7036
1953-54	222	214	85	2705	6083	9000	2205	7477	1153	1245	66	5849	878	381	939	808	78	144	1793	1601	7365
1954-55	246	235	88	2803	2679	9588	2390	8160	1207	1283	173	6362	941	420	1062	871	82	154	1707	1983	7883
1955-56	280	268	90	2872	7003	10388	2620	8906	1225	1417	208	6839	1049	436	1204	927	83	168	1740	1953	8556
1956-57	291	275	90	2907	18071	11313	2810	9646	1270	1564	-46	7312	1093	442	1275	950	85	177	2190	1736	9141
1957-58	296	283	92	2942	29418	11569	3019	10235	1315	1434	14	7666	1131	503	1355	998	84	186	1847	1925	9145
1958-59	300	287	94	3005	27528	12425	3205	10862	1501	1591	277	8069	1233	550	1372	1100	88	196	1868	1960	9843
1959-60	336	322	97	3127	16541	13686	3585	12060	1426	1680	152	8853	1323	620	1571	1214	94	209	2150	2286	10808
1960-61	344	377	98	3133	54254	14553	3740	12883	1315	1625	480	9391	1422	673	1742	1256	96	224	2175	2603	11612
1961-62	364	356	99	3214	46324	14881	3787	13261	1498	1699	-218	9676	1543	603	1725	1402	96	234	2470	2205	1018
1962-63	381	368	100	3315	38188	16071	4151	14269	1622	1673	260	10366	1652	663	1917	1451	100	250	2494	2620	12792
1963-64	415	400	105	3461	18129	17802	4513	16000	1683	1785	125	11177	1804	773	2146	1602	108	269	3163	2873	14146
1964-65	451	434	107	3604	12656	19672	5042	17379	1715	1784	569	12080	2066	917	2493	1854	111	287	3049	3485	15436
1965-66	473	457	115	3804	19058	20497	5246	18587	1663	1663	117	12818	2408	911	2745	2058	113	302	3138	3629	16189
1966-67	527	506	119	3902	23394	22535	5644	20177	1591	1762	360	13791	2727	991	2838	2168	113	318	3487	3711	17894
1967-68	547	524	122	4030	21275	24032	6126	22194	1691	1770	128	15009	3082	1112	3044	2372	120	396	3568	4155	18740
1968-69	600	573	125	4172	15910	26951	6756	24618	1749	1948	668	16161	3364	1299	3389	2536	123	422	3901	4276	20980
1969-70	662	629	128	4340	13043	29764	7401	27582	1909	2036	495	17702	3677	1490	3714	2755	124	462	4755	4764	23110
1970-71	717	695	130	4478	19184	32702	8053	30698	2022	1952	445	19419	4258	1535	4277	2932	125	513	5054	5122	25890
1971-72	775	770	130	4507	41581	36002	8866	33793	2270	1916	-111	21325	4831	1749	4355	3285	128	550	5638	5238	29041

Source to Appendix Data Table A6.

GSP from *Chapter Five*.

TPI from *Australian National Accounts* (CBCS, Canberra).

TEMP from *Employment and Unemployment* (CBCS, Canberra).

AUSEMP from *Employment and Unemployment* (CBCS, Canberra).

UNEMPL from *Employment and Unemployment* (CBCS, Canberra).

GDP from *Australian National Accounts* (CBCS, Canberra).

MGFPRD from *Australian National Accounts* (CBCS, Canberra).

GNFPRD from *Australian National Accounts* (CBCS, Canberra).

METPRD from *Primary Industries* (CBCS, Hobart).

WOLPRD from *Primary Industries* (CBCS, Hobart).

Δ Stock from *Australian National Accounts* (CBCS, Canberra).

PCONSP from *Australian National Accounts* (CBCS, Canberra).

GCONSP from *Australian National Accounts* (CBCS, Canberra).

INVDWL from *Australian National Accounts* (CBCS, Canberra).

INVOTH from *Australian National Accounts* (CBCS, Canberra).

INVGOT from *Australian National Accounts* (CBCS, Canberra).

PIDXUK from *Quarterly Summary of Statistics* (CBCS, Canberra).

NINCUK from *Quarterly Summary of Statistics* (CBCS, Canberra).

EXPORT from *Australian National Accounts* (CBCS, Canberra).

IMPORT from *Australian National Accounts* (CBCS, Canberra).

AUSPIN from *Australian National Accounts* (CBCS, Canberra).

Appendix Table A7.1

Location Quotients for Tasmanian Industries (On Civilian Male Employment Basis)*

Year	Forestry, Fishing and Trapping	Mining and Quarrying	Electricity, Gas and Water	Building and Construction	Transport and Commun- ication	Property and Finance	Commerce	Public Authority (n.e.i.)	Community and Business Services	Amuse- ments, Hotels etc.	Manu- facturing
1948-49	2.35	1.75		1.56	.88	.80	.94	1.04	1.02		.81
1949-50	2.37	1.67		1.53	.90	.79	.94	1.10	1.07		.80
1950-51	2.41	1.56		1.55	.92	.82	.92	1.15	1.10		.77
1951-52	2.46	1.57		1.54	.92	.80	.93	1.21	1.10		.77
1952-53	2.50	1.72		1.73	.90	.77	.92	1.14	1.09		.75
1953-54	2.65	1.62		1.60	.92	.77	.93	1.20	1.11		.76
1954-55	2.62	1.65		1.57	.96	.81	.94	1.20	1.09		.76
1955-56	2.52	1.69		1.32	.99	.78	.94	1.22	1.11		.80
1956-57	2.54	1.76		1.37	.98	.75	.95	1.21	1.12		.80
1957-58	2.58	1.71		1.46	.97	.76	.89	1.15	1.10		.82
1958-59	2.65	1.75		1.42	.98	.74	.91	1.18	1.09		.82
1959-60	2.61	1.86		1.35	.98	.73	.90	1.16	1.07		.85
1960-61	1.91	2.18	1.05	1.06	1.11	.88	1.01	1.17	1.10	.84	.85
1961-62	2.38	2.24	1.08	1.10	1.12	.87	1.02	1.15	.96	.79	.84
1962-63	2.38	2.21	1.11	1.12	1.09	.88	1.02	1.21	.98	.76	.85
1963-64	2.53	2.13	1.16	1.11	1.10	.90	1.04	1.24	.96	.77	.83
1964-65	2.75	2.12	1.17	1.09	1.08	.87	1.06	1.28	1.00	.74	.83
1965-66	2.44	2.01	1.14	1.14	1.11	.86	.93	1.04	.98	.84	.88
1966-67	2.40	2.01	1.14	1.19	1.09	.87	.90	1.02	.99	.86	.89
1967-68	2.18	2.27	1.13	1.12	1.09	.88	.93	1.02	.99	.89	.91
1968-69	2.27	2.29	1.15	1.11	1.07	.86	.91	1.03	.97	.86	.90
1969-70	2.26	2.20	1.20	1.14	1.05	.85	.91	1.00	.99	.95	.92
1970-71	2.38	2.30	1.18	1.05	1.03	.87	.90	1.00	.98	.98	.90

* Due to the reclassification of Tasmanian industry groups, location quotients for Electricity, Gas and Water, and for Amusements, Hotels, etc., cannot be computed for years before 1960-61.

Appendix Table A7.2
Basic and Nonbasic Tasmanian Employment (Civilian Males),
By Industry Groups, 1948-49 to 1970-71 (Thousands)

YEAR	Forestry, Fishing, Trapping				Mining and Quarrying				Manufacturing (C)				Electricity, gas, water				Building and Construction				Transport and Communication			
	(A)		(B)		(A)		(B)		(A)		(B)		(A)		(B)		(A)		(B)		(A)		(B)	
	Non- Basic	Basic	Non- Basic	Basic	Non- Basic	Basic	Non- Basic	Basic	Non- Basic	Basic	Non- Basic	Basic	Non- Basic	Basic	Non- Basic	Basic	Non- Basic	Basic	Non- Basic	Basic	Non- Basic	Basic	Non- Basic	Basic
1948-49	1.21	.89	2.1	-	1.16	1.54	2.7	-	4.6	13.3	9.9	8.0					3.20	5.7	8.9	-	-	7.8	-	7.8
1949-50	1.21	.89	2.1	-	1.12	1.68	2.8	-	4.7	13.6	10.1	8.2					3.26	6.14	9.4	-	-	8.2	-	8.2
1950-51	1.23	.87	2.1	-	.97	1.73	2.7	-	4.7	13.7	10.2	8.2					3.66	6.64	10.3	-	-	8.4	-	8.4
1951-52	1.25	.85	2.1	-	1.05	1.85	2.9	-	4.7	13.6	10.1	8.2					3.65	6.65	10.3	-	-	8.7	-	8.7
1952-53	1.26	.84	.1	-	1.34	1.86	3.2	-	4.7	13.7	10.2	8.2					4.50	6.20	10.7	-	-	8.5	-	8.5
1953-54	1.37	.83	2.1	-	1.14	1.86	3.0	-	4.9	14.4	10.7	8.6					3.90	6.50	10.4	-	-	8.7	-	8.7
1954-55	1.36	.84	2.2	-	1.19	1.81	3.0	-	5.0	14.7	10.9	8.8					3.78	6.62	10.4	-	-	9.2	-	9.2
1955-56	1.25	.85	2.2	-	1.23	1.77	3.0	-	5.3	15.6	11.5	9.4					2.13	6.67	8.8	-	-	9.6	-	9.6
1956-57	1.21	.89	2.1	-	1.34	1.76	3.1	-	5.3	15.8	11.6	9.5					2.40	6.50	8.9	-	-	9.6	-	9.6
1957-58	1.29	.81	2.0	-	1.16	1.64	2.8	-	5.7	16.7	12.4	10.0					2.96	6.44	9.4	-	-	9.6	-	9.6
1958-59	1.31	.70	2.1	-	1.16	1.54	2.7	-	5.8	16.9	12.5	10.2					2.71	6.49	9.2	-	-	9.7	-	9.7
1959-60	1.35	.75	2.1	-	1.34	1.56	2.9	-	6.2	18.2	13.5	10.9					2.30	6.60	8.9	-	-	9.7	-	9.7
1960-61	.38	.42	2.1	-	1.84	1.56	3.4	-	5.7	16.8	12.4	10.1	.14	2.86	-	3.0	.55	9.25	-	9.8	.94	8.56	-	9.5
1961-62	.58	.42	.8	-	1.83	1.47	3.3	-	5.8	17.2	12.7	10.3	.23	2.87	-	3.1	.87	8.73	-	9.6	1.0	8.30	-	9.3
1962-63	.58	.42	1.0	-	1.75	1.45	3.2	-	6.0	17.5	13.0	10.5	.32	2.88	-	3.2	1.06	8.84	-	9.8	.75	8.35	-	9.1
1963-64	.61	.39	1.0	-	1.64	1.46	3.1	-	6.1	18.0	13.3	10.8	.47	2.93	-	3.4	1.0	9.10	-	10.1	.84	8.46	-	9.3
1964-65	.70	.40	1.0	-	1.63	1.47	3.1	-	6.2	18.2	13.5	10.9	.50	2.90	-	3.4	.83	9.27	-	10.1	.68	8.52	-	9.2
1965-66	.59	.41	1.1	-	1.61	1.59	3.2	-	6.7	19.5	14.5	11.7	.43	3.07	-	3.5	1.46	10.44	-	11.9	.97	8.83	-	9.8
1966-67	.58	.42	1.0	-	1.66	1.64	3.3	-	6.9	20.0	14.8	12.1	.44	3.16	-	3.6	1.93	10.17	-	12.1	.81	8.99	-	9.8
1967-68	.54	.46	1.0	-	2.18	1.72	3.9	-	7.0	20.4	15.1	12.3	.41	3.19	-	3.6	1.24	10.36	-	11.6	.82	9.08	-	9.9
1968-69	.56	.44	1.0	-	2.37	1.83	4.2	-	7.1	20.7	15.3	12.5	.48	3.22	-	3.7	1.17	10.63	-	11.8	.65	9.25	-	9.9
1969-70	.56	.44	1.0	-	2.40	2.0	4.4	-	7.2	21.1	15.6	12.7	.63	3.17	-	3.8	1.50	10.70	-	12.2	.47	9.43	-	9.9
1970-71	.58	.42	1.0	-	2.72	2.08	4.4	-	7.2	21.0	15.6	12.6	.58	3.22	-	3.8	.54	10.86	-	11.4	.28	9.52	-	9.8

(Continued)

Appendix Table A7.2

YEAR	Property and Finance				Commerce				Public Authority (n.e.i.)				Community and Bus Services				Amusements, Hotels etc.				Total Non-Basic	Total Basic	Total Non-Basic	Total Basic	Total
	(A)		(B)		(A)		(B)		(A)		(B)		(A)		(B)		Total Basic	(B) Total Basic							
	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic									
1948-49	-	1.3	-	1.3	-	7.2	-	7.2	.11	2.79	-	2.9	.11	5.29	-	5.4			10.39	45.81	23.6	32.6	56.2		
1949-50	-	1.3	-	1.3	-	7.4	-	7.4	.29	2.91	-	3.2	.37	5.33	-	5.7			10.95	47.45	24.4	34.0	58.4		
1950-51	-	1.4	-	1.4	-	7.5	-	7.5	.46	3.04	-	3.5	.54	5.36	-	5.9			11.56	48.64	25.3	34.9	60.2		
1951-52	-	1.4	-	1.4	-	7.6	-	7.6	.64	3.06	3.7	-	.55	5.45	-	6.0			11.84	49.16	29.1	31.9	61.0		
1952-53	-	1.4	-	1.4	-	7.7	-	7.7	.44	3.16	-	3.6	.50	5.60	-	6.1			12.74	48.96	26.2	35.5	61.7		
1953-54	-	1.4	-	1.4	-	7.9	-	7.9	.62	3.08	3.7	-	.61	5.59	-	6.2			12.54	50.26	30.0	32.8	62.8		
1954-55	-	1.5	-	1.5	-	8.1	-	8.1	.62	3.08	3.7	-	.51	5.69	-	6.2			12.46	51.54	30.2	33.8	64.0		
1955-56	-	1.5	-	1.5	-	8.2	-	8.2	.68	3.12	3.8	-	.59	5.91	-	6.5			11.18	53.22	29.2	35.2	64.4		
1956-57	-	1.5	-	1.5	-	8.3	-	8.3	.68	3.22	3.9	-	.73	6.07	-	6.8			11.66	53.64	29.5	35.7	65.3		
1957-58	-	1.6	-	1.6	-	8.1	-	8.1	.50	3.30	-	3.8	.63	6.27	-	6.9			12.74	54.46	26.7	40.0	66.7		
1958-59	-	1.6	-	1.6	-	8.2	-	8.2	.59	3.31	-	3.9	.56	6.34	-	6.9			12.13	54.87	26.5	40.5	67.0		
1959-60	-	1.7	-	1.7	-	8.5	-	8.5	.54	3.36	-	3.9	.47	6.73	-	7.2			12.20	57.10	27.4	41.9	69.3		
1960-61	-	2.3	-	2.3	-	11.5	-	11.5	.52	3.08	-	3.6	.43	4.27	-	4.7	-	1.9	-	1.9	10.50	62.50	16.6	56.4	73.0
1961-62	-	2.3	-	2.3	-	11.6	-	11.6	.47	3.13	-	3.6	-	5.0	-	5.0	-	1.8	-	1.8	10.78	62.82	17.0	56.6	73.6
1962-63	-	2.4	-	2.4	-	11.8	-	11.8	.68	3.22	3.9	-	-	5.3	-	5.3	-	1.8	-	1.8	11.14	63.96	21.1	54.0	75.1
1963-64	-	2.6	-	2.6	-	12.5	-	12.5	.80	3.30	4.1	-	-	5.4	-	5.4	-	1.9	-	1.9	11.46	66.04	21.5	56.0	77.5
1964-65	-	2.6	-	2.6	-	12.7	-	12.7	.94	3.36	4.3	-	-	5.7	-	5.7	-	1.9	-	1.9	11.48	67.02	22.0	56.5	78.5
1965-66	-	2.7	-	2.7	-	11.3	-	11.3	.14	3.46	-	3.6	-	6.2	-	6.2	-	2.2	-	2.2	11.90	69.70	18.7	62.9	81.6
1966-67	-	2.8	-	2.8	-	11.1	-	11.1	.07	3.63	-	3.7	-	6.5	-	6.5	-	2.4	-	2.4	12.39	70.81	19.1	64.1	83.2
1967-68	-	2.9	-	2.9	-	11.4	-	11.4	.07	3.73	-	3.8	-	6.7	-	6.7	-	2.6	-	2.6	12.26	72.54	20.0	64.8	84.8
1968-69	-	3.0	-	3.0	-	11.4	-	11.4	.16	3.84	-	4.0	-	6.9	-	6.9	-	2.7	-	2.7	12.49	73.91	20.5	65.9	86.4
1969-70	-	3.1	-	3.1	-	11.5	-	11.5	-	4.0	-	4.0	-	7.3	-	7.3	-	3.1	-	3.1	12.76	75.84	21.0	67.6	88.6
1970-71	-	3.2	-	3.2	-	11.6	-	11.6	-	4.2	-	4.2	-	7.7	-	7.7	-	3.4	-	3.4	11.90	77.20	21.4	67.6	89.1

Explanatory Notes to Appendix Table A7.2:

- (A) Estimates derived by pro-rata method.
 (B) Estimates derived by all-or-nothing method.
 (C) A 5-year average basic/nonbasic ratio is used to divide total manufacturing employment into the basic and the nonbasic portions.

Appendix Table A7.3

Basic and Nonbasic Tasmanian Wages and Salaries, By Industry Groups, 1948-49 to 1970-71 (\$m.)^a

	Primary Production				Mining and Quarrying				Manufacturing (C)				Electricity, Gas and Water				Building and Construction				Transport and Communication				Property and Finance				Commerce				
	(A)		(B)		(A)		(B)		(A)		(B)		(A)		(B)		(A)		(B)		(A)		(B)		(A)		(B)		(A)		(B)		
	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic			
1948-49	1.7	1.2	2.9	-	.9	1.1	2.0	-	4.2	12.7	8.9	8.0	-	3.5	-	3.5	1.1	1.9	3.0	-	-	6.2	-	6.2	-	2.5	-	2.5	-	9.0	-	9.0	
1949-50	2.0	1.4	3.4	-	1.0	1.4	2.4	-	5.0	14.9	10.4	9.5	-	4.2	-	4.2	1.2	2.3	3.5	-	-	7.3	-	7.3	-	2.9	-	2.9	-	10.6	-	10.6	
1950-51	2.5	1.7	4.2	-	1.1	1.9	3.0	-	6.1	18.5	12.9	11.7	-	5.1	-	5.1	1.5	2.8	4.3	-	-	9.0	-	9.0	-	3.6	-	3.6	-	13.1	-	13.1	
1951-52	3.3	2.2	5.5	-	1.4	2.4	3.8	-	7.9	24.0	16.7	15.2	-	6.6	-	6.6	2.0	3.6	5.6	-	-	11.7	-	11.7	-	4.7	-	4.7	-	17.1	-	17.1	
1952-53	3.7	2.5	6.2	-	1.8	2.5	4.3	-	9.0	27.0	18.9	17.1	-	7.5	-	7.5	2.7	3.6	6.3	-	-	13.2	-	13.2	-	5.3	-	5.3	-	19.2	-	19.2	
1953-54	4.1	2.5	6.6	-	1.8	2.8	4.6	-	9.5	29.0	20.2	18.3	-	8.0	-	8.0	2.5	4.3	6.8	-	-	14.1	-	14.1	-	5.6	-	5.6	-	20.6	-	20.6	
1954-55	4.4	2.7	7.1	-	1.9	3.0	4.9	-	10.2	30.8	21.5	19.5	-	8.5	-	8.5	2.6	4.6	7.2	-	-	15.0	-	15.0	-	6.0	-	6.0	-	21.9	-	21.9	
1955-56	4.7	3.0	7.7	-	2.2	3.2	5.4	-	11.1	33.7	23.5	21.3	-	9.3	-	9.3	1.9	6.0	7.9	-	-	16.4	-	16.4	-	6.6	-	6.6	-	23.9	-	23.9	
1956-57	5.0	3.3	8.3	-	2.5	3.3	5.8	-	12.0	36.0	25.2	22.8	-	10.0	-	10.0	2.3	6.1	8.4	-	-	17.6	-	17.6	-	7.0	-	7.0	-	25.7	-	25.7	
1957-58	5.2	3.3	8.5	-	2.4	3.5	5.9	-	12.3	37.1	25.9	23.5	-	10.3	-	10.3	2.7	6.0	8.7	-	-	18.1	-	18.1	-	7.2	-	7.2	-	26.4	-	26.4	
1958-59	5.5	3.3	8.8	-	2.6	3.5	6.1	-	12.7	38.3	26.7	24.3	-	10.6	-	10.6	2.7	6.3	9.0	-	-	18.7	-	18.7	-	7.5	-	7.5	-	27.3	-	27.3	
1959-60	5.9	3.7	9.6	-	3.1	3.6	6.7	-	14.0	42.0	29.4	26.6	-	11.7	-	11.7	2.5	7.3	9.8	-	-	20.5	-	20.5	-	8.2	-	8.2	-	29.9	-	29.9	
1960-61	4.8	5.3	10.1	-	3.8	3.3	7.1	-	14.7	44.3	31.0	28.0	-	12.3	-	12.3	-	10.3	-	10.3	-	-	21.6	-	21.6	-	8.6	-	8.6	-	31.5	-	31.5
1961-62	6.2	4.5	10.7	-	4.1	3.4	7.5	-	16.4	45.6	32.5	29.5	-	12.9	-	12.9	1.0	9.9	-	10.9	-	-	22.7	-	22.7	-	9.1	-	9.1	-	33.1	-	33.1
1962-63	6.4	4.6	11.0	-	4.2	3.5	7.7	-	16.0	48.0	33.5	30.5	1.3	12.0	-	13.3	1.2	10.0	-	11.2	-	-	23.4	-	23.4	-	9.3	-	9.3	-	34.1	-	34.1
1963-64	7.2	4.7	11.9	-	4.4	4.0	8.4	-	17.3	52.0	36.3	33.0	2.0	12.5	-	14.5	1.2	11.0	-	12.2	-	-	25.4	-	25.4	-	10.1	-	10.1	-	37.0	-	37.0
1964-65	8.2	4.7	12.9	-	4.8	4.3	9.1	-	18.6	56.4	39.3	35.7	2.3	13.4	-	15.7	-	13.2	-	13.2	-	-	27.5	-	27.5	-	11.0	-	11.0	-	40.0	-	40.0
1965-66	8.3	5.8	14.1	-	5.0	4.9	9.9	-	20.5	61.5	43.0	39.0	2.1	15.0	-	17.1	1.8	12.6	-	14.4	-	-	30.0	-	30.0	-	12.0	-	12.0	-	43.8	-	43.8
1966-67	9.0	6.5	15.5	-	5.5	5.4	10.9	-	22.3	67.7	47.0	43.0	2.3	16.5	-	18.8	2.5	13.3	15.8	-	-	33.0	-	33.0	-	13.2	-	13.2	-	48.2	-	48.2	
1967-68	9.1	7.7	16.8	-	6.6	5.2	11.8	-	24.2	73.0	51.0	46.2	2.3	18.1	-	20.4	1.8	15.3	-	17.1	-	-	35.7	-	35.7	-	14.2	-	14.2	-	52.0	-	52.0
1968-69	10.1	8.0	18.1	-	7.2	5.5	12.7	-	25.3	76.7	53.4	48.6	2.9	19.1	-	22.0	1.8	16.7	-	18.5	-	-	38.6	-	38.6	-	15.4	-	15.4	-	56.3	-	56.3
1969-70	11.4	9.0	20.4	-	7.8	6.5	14.3	-	29.3	88.7	62.0	56.0	4.1	20.6	-	24.7	2.5	18.3	-	20.8	-	-	43.4	-	43.4	-	17.3	-	17.3	-	63.3	-	63.3
1970-71	13.9	9.0	22.9	-	9.1	7.0	16.1	-	33.0	100.0	70.0	63.0	4.2	23.5	-	27.7	-	23.3	-	23.3	-	-	48.7	-	48.7	-	19.4	-	19.4	-	71.0	-	71.0

^a Estimates for Tasmanian industry wages and salaries for the period 1948-49 to 1970-71 were computed from the 1964-65 Tasmanian industry distribution of wages and salaries supplied directly by the Bureau. Location Quotients are taken from Appendix Table A7.1.

(Continued)

Appendix Table A7.3 (Continued)

Year	Public Authority (n.e.i.)				Community and Business Services				Amusements and Hotels etc.				(A)		(B)		Total
	(A)		(B)		(A)		(B)		(A)		(B)		Total	Total	Total		
	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic	Basic	Non-Basic		
1948-49	-	10.3	-	10.3	-	3.6	-	3.6	-	2.0	-	2.0	8.0	54.0	16.8	45.2	62
1949-50	-	12.1	-	12.1	-	4.3	-	4.3	-	2.3	-	2.3	9.2	63.8	19.7	53.3	73
1950-51	2.5	12.4	14.9	-	-	5.3	-	5.3	-	2.9	-	2.9	13.7	76.3	39.3	50.7	90
1951-52	3.2	16.2	19.4	-	-	6.9	-	6.9	-	3.7	-	3.7	17.8	99.2	51.0	66.0	117
1952-53	3.6	18.2	21.8	-	-	7.7	-	7.7	-	4.2	-	4.2	21.0	111.0	57.5	74.5	132
1953-54	3.9	19.5	23.4	-	-	8.3	-	8.3	-	4.5	-	4.5	21.8	119.2	61.6	79.4	141
1954-55	4.1	20.8	24.9	-	-	8.8	-	8.8	-	4.8	-	4.8	23.2	126.8	65.6	84.4	150
1955-56	4.5	22.7	27.2	-	-	9.6	-	9.6	-	5.2	-	5.2	24.4	139.6	71.7	92.3	164
1956-57	4.9	24.3	29.2	-	-	10.3	-	10.3	-	5.6	-	5.6	26.7	149.3	76.9	99.1	176
1957-58	5.0	25.0	30.0	-	-	10.6	-	10.6	-	5.8	-	5.8	27.6	153.4	79.0	102.0	181
1958-59	5.2	25.8	31.0	-	-	10.9	-	10.9	-	6.0	-	6.0	28.7	158.3	81.6	105.4	187
1959-60	5.7	28.3	34.0	-	-	12.0	-	12.0	-	6.6	-	6.6	31.2	173.8	89.5	115.5	205
1960-61	6.0	29.8	35.8	-	-	12.7	-	12.7	-	6.9	-	6.9	29.3	186.7	84.0	132.0	216
1961-62	6.3	31.3	37.6	-	-	13.3	-	13.3	-	7.3	-	7.3	34.0	193.0	88.3	138.7	227
1962-63	6.5	32.3	38.8	-	-	13.7	-	13.7	-	7.5	-	7.5	35.6	198.4	91.0	143.0	234
1963-64	7.0	35.0	42.0	-	-	14.9	-	14.9	-	8.1	-	8.1	39.1	214.9	98.6	155.4	254
1964-65	7.6	38.0	45.6	-	-	16.1	-	16.1	-	8.8	-	8.8	41.5	233.5	106.9	168.1	275
1965-66	-	49.7	-	49.7	-	17.6	-	17.6	-	9.6	-	9.6	37.7	262.3	67.0	233.0	300
1966-67	-	54.7	-	54.7	-	19.3	-	19.3	-	10.5	-	10.5	41.6	288.4	89.2	240.8	330
1967-68	-	59.0	-	59.0	-	20.9	-	20.9	-	11.4	-	11.4	44.5	312.5	79.6	277.4	357
1968-69	-	64.0	-	64.0	-	22.6	-	22.6	-	12.3	-	12.3	48.0	338.0	84.2	301.8	386
1969-70	-	72.0	-	72.0	-	25.4	-	25.4	-	13.9	-	13.9	55.6	378.4	96.7	337.3	434
1970-71	-	80.5	-	80.5	-	28.5	-	28.5	-	15.6	-	15.6	60.5	426.5	109.0	378.0	487

Explanatory Notes to Appendix Table A7.3:

(A) Estimates derived by the pro-rata method.

(B) Estimates derived by the all-or-nothing method.

(C) A 5-year average basic/nonbasic ratio is used to divide wages and salaries in manufacturing industries into the basic and the nonbasic portions.

Appendix Table A7.4

Time Series used in Chapter Seven

Year	P	E ₁	Y _{e1}	E ₂	Y _{e2}	A ₁ =(P+E ₁)	A ₂ =(P+E ₂)	a ₁ =(p+e ₁)	a ₂ =(p+e ₂)	y _{e1}	y _{e2}	P	e ₁	e ₂	ENB ₁	EB ₁	ENB ₂	EB ₂	Y _p
1948-49	15	27.8	56.2	19.0	65.0	42.8	34.0	161	128	211	244	56	104	71	32.6	23.6	45.8	10.4	99
1949-50	12	37.7	71.3	27.2	81.8	49.7	39.2	182	143	260	298	44	138	99	34.0	24.4	47.5	10.9	121
1950-51	14	73.3	75.7	47.7	101.3	87.3	61.7	308	218	267	357	49	258	168	34.9	25.3	48.6	11.6	163
1951-52	16	79.0	93.0	45.8	126.2	95.0	61.8	324	210	317	430	54	269	156	31.9	29.1	49.2	11.8	186
1952-53	18	87.5	104.5	51.0	141.0	105.5	69.0	348	228	345	465	59	289	168	35.5	26.2	48.9	12.7	209
1953-54	25	83.6	105.4	43.8	145.2	108.6	68.8	350	222	340	470	81	270	141	32.8	30.0	50.3	12.5	214
1954-55	27	94.6	113.4	52.2	155.8	121.6	79.2	388	253	362	498	86	302	167	33.8	30.2	51.5	12.5	235
1955-56	30	111.7	125.3	64.4	172.6	141.7	94.4	446	297	395	543	94	351	202	35.2	29.2	53.2	11.2	267
1956-57	31	108.9	135.1	58.7	185.3	139.9	89.7	430	276	415	570	95	335	180	35.7	29.5	53.6	11.7	275
1957-58	37	109.0	137.0	57.6	188.4	146.0	94.6	440	285	413	568	111	329	173	40.0	26.7	54.5	12.7	283
1958-59	39	106.6	141.4	53.7	194.3	145.6	92.7	430	273	417	573	115	314	158	40.5	26.5	54.9	12.1	287
1959-60	41	118.5	156.5	60.2	214.8	159.5	101.2	464	294	455	625	119	345	175	41.9	27.4	57.1	12.2	316
1960-61	46	109.0	174.0	54.3	228.7	155.0	100.3	443	286	498	655	132	312	155	56.4	16.6	62.5	10.5	329
1961-62	48	114.3	181.3	60.0	236.0	162.3	108.0	458	306	513	668	136	324	170	56.6	17.0	62.8	10.8	344
1962-63	51	120.0	186.0	64.6	241.4	171.0	115.6	477	323	520	673	142	335	180	54.0	21.1	64.0	11.1	357
1963-64	56	131.6	201.4	72.1	260.9	187.6	128.1	516	352	553	718	154	362	198	56.0	21.5	66.0	11.5	389
1964-65	60	144.9	216.1	79.5	281.5	204.9	139.5	560	381	590	770	164	396	217	56.5	22.0	67.0	11.5	421
1965-66	64	99.0	282.0	69.7	311.3	163.0	133.7	440	361	760	840	173	267	188	62.9	18.7	69.7	11.9	445
1966-67	68	125.2	296.8	77.6	344.4	193.2	145.6	517	390	795	922	182	335	208	64.1	19.1	70.8	12.4	490
1967-68	75	100.6	323.4	65.5	368.5	175.6	140.5	465	373	856	978	199	265	179	64.8	20.0	72.5	12.3	509
1968-69	80	110.2	363.8	74.0	400.0	190.2	154.0	497	402	950	1045	210	288	194	65.9	20.5	73.9	12.5	554
1969-70	91	128.7	399.3	87.6	440.4	219.7	178.6	567	460	1030	1135	235	332	226	67.6	21.0	75.8	12.8	619
1970-71	99	138.0	444.0	89.5	492.5	237.0	188.5	606	494	1140	1260	254	354	229	67.7	21.4	77.2	11.9	681

Explanatory Notes to Appendix Table A7.4:

P - Components of personal income in Tasmania, consisting of "cash benefits from public authority" and "all other income".

E - Earned income in export industries, consisting of "unincorporated farm income" and "total basic wages and salaries" from Appendix Table A7.3.

Y_e - Endogenous income, consisting of "unincorporated non-farm proprietors' income", "dwelling rents", and "total nonbasic wages and salaries".

Variables with subscripts 1 and 2 refer to estimates derived by the all-or-nothing method and by the pro-rata method respectively.

p, e₁, e₂, etc., are per capita variables of the corresponding P, E₁, E₂, etc.

ENB - total nonbasic Tasmanian employment (civilian males).

EB - total basic Tasmanian employment (civilian males).

Y_p - total personal income received in Tasmania.

Appendix Table A7.5

*Location Quotients for Tasmanian Manufacturing Industries, by Class,
1961-62 to 1965-66**

Industry Class	1961-62	1962-63	1963-64	1964-65	1965-66
1	1.13	1.27	1.23	1.21	1.16
2	.62	.60	.59	.57	.56
3	.72	.72	.70	.76	.71
4	.75	.74	.73	.72	.72
5	-	-	-	-	-
6	1.70	1.69	1.78	1.96	1.97
7	.31	.30	-	-	-
8	.29	.25	.24	.28	.24
9	1.45	1.48	1.42	1.40	1.40
10	2.35	2.46	2.58	2.58	2.63
11	.69	.88	.84	.83	.79
12	2.13	2.20	2.26	2.18	2.16
13	.22	.20	.18	.19	.18
14	-	-	-	-	-
15	.15	.14	.14	.12	.12
16	.93	.96	.98	.99	.96

* On employment basis.

BIBLIOGRAPHYI. Books

- [1] Almon, C. Jr. *Matrix Methods in Economics*, Addison-Wesley Publishing Company, Massachusetts, 1967.
- [2] Bolton, R. E. *Defense Purchases and Regional Growth*, The Brookings Institution, Washington, D.C., 1966.
- [3] Borts, G. H. "The Estimation of Produced Income by State and Region" in *The Behaviour of Income Shares*, Studies in Income and Wealth, Vol. 27, National Bureau of Economic Research, New York, 1964.
- [4] ——— and Stein, J. L. *Economic Growth in a Free Market*, Columbia University Press, New York, 1964.
- [5] Boudeville, J. R. *Problems of Regional Economic Planning*, Edinburgh U.P., Edinburgh, Scotland, 1966.
- [6] Box, G.E.P. and Jenkins, G. M. *Time Series Analysis, Forecasting and Control*, Holden-Day, Inc., San Francisco, 1970.
- [7] Brown, R. G. *Smoothing, Forecasting and Prediction of Discrete Time Series*, Prentice-Hall, New Jersey, 1963.
- [8] ——— *Statistical Forecasting for Inventory Control*, McGraw-Hill, New York, 1959.
- [9] Cairncross, A. K. (editor). *The Scottish Economy*, Cambridge University Press, 1954.
- [10] Chau, L. C. *An Econometric Model for Forecasting Income and Employment in Hawaii*, Economic Research Center, University of Hawaii, Hawaii, June, 1970.
- [11] Chisholm, R. K. and Whitaker, G. R. Jr. *Forecasting Methods*, R. D. Irwin, Illinois, 1971.
- [12] Czamanski, S. *An Econometric Model of Nova Scotia*, Institute of Public Affairs, Halifax, Canada, 1968.
- [13] Davies, J. L. (editor). *Atlas of Tasmania*, Lands and Surveys Department, Hobart, 1965.
- [14] Doob, J. L. *Stochastic Processes*, John Wiley and Sons, Inc., New York, 1953.

- [15] Draper, N. R. and Smith, H. *Applied Regression Analysis*, John Wiley and Sons, Inc., New York, 1966.
- [16] Duesenberry, J. S., Fromm, G., Klein, L. R. and Kuh, E. (editors). *The Brookings Quarterly Econometric Model of the U.S. Economy*, Rand McNally, Chicago, 1965.
- [17] Evans, M. K. and Klein, L. R. *The Wharton Econometric Forecasting Model*, University of Pennsylvania Department of Economics Studies in Quantitative Economics, No. 2, University of Pennsylvania Press, Philadelphia, 1968.
- [18] Fair, R. C. *A Short-Run Forecasting Model of the United States Economy*, Heath Lexington Books Company, Massachusetts, 1971.
- [19] Friedmann, J. and Alonso, W. (editors). *Regional Development and Planning: A Reader*, M.I.T. Press, Cambridge, 1964.
- [20] Garston, G. J. and Worton, D. A. "Problems in the Estimation of Industry Output in Current and Constant Dollars in Canada" in *The Industrial Composition of Income and Product*, Studies in Income and Wealth, Vol. 32, National Bureau of Economic Research, New York, 1968.
- [21] Ghali, M. *A Survey of the Planning and Forecasting Models for the State of Hawaii*, Economic Research Center, University of Hawaii, Hawaii, September, 1970.
- [22] Goldberger, A. S. *Econometric Theory*, John Wiley and Sons, Inc., New York, 1964.
- [23] Green, R. J. *A Long-Range Econometric Forecasting Model for Illinois*, mimeographed, Bureau of Economic and Business Research, University of Illinois, March, 1967.
- [24] Hamilton, H. R., Goldstone, S. E., Milliman, J. W., Pugh, A. L., Roberts, E. B. and Zellner, A. *Systems Simulation for Regional Analysis: An Application to River-Basin Planning*, M.I.T. Press, Cambridge, 1969.
- [25] Hirsch, W. L. (editor). *Regional Accounts for Policy Decisions, Papers presented at the Conference on Regional Accounts, 1964*, published for Resources for the Future by the John Hopkins Press, Baltimore, 1966.
- [26] Hoover, E. M. *The Location of Economic Activity*, McGraw-Hill, New York, 1963.

- [27] Hoover, E. M. *An Introduction to Regional Economics*, Alfred A. Knopf, New York, 1971.
- [28] Hunter Valley Research Foundation, *Tasmania in the Seventies*, A Growth Study commissioned by The Federation of Tasmanian Chambers of Commerce, and by The Government of Tasmania, Newcastle, 1970.
- [29] Intriligator, M. D. (editor). *Frontiers of Quantitative Economics*, North-Holland Publishing Company, Amsterdam, 1971.
- [30] Isard, W. *Methods of Regional Analysis: An Introduction to Regional Science*, M.I.T. Press, Cambridge, 1960.
- [31] Johnston, J. *Econometric Methods*, McGraw-Hill, New York, 1963.
- [32] Kain, J. F. and Meyer, J. R. *Essays in Regional Economics*, Harvard University Press, Cambridge, 1971.
- [33] Kerr, A. *State and Regional Income Estimation - Theory and Practice*, University of Western Australia Press, Nedlands, 1963.
- [34] Klein, L. R. and Goldberger, A. S. *An Econometric Model of the United States 1929-1952*, North-Holland Publishing Company, Amsterdam, 1955.
- [35] Kmenta, J. *Elements of Econometrics*, Macmillan, New York, 1971.
- [36] Koyck, L. M. *Distributed Lags and Investment Analysis*, North-Holland Publishing Company, Amsterdam, 1954.
- [37] McCrone, G. *Scotland's Economic Progress 1951-60*, George Allen and Unwin, London, 1965.
- [38] McKee, D. L., Dean, R. D. and Leahy, W. H. (editors). *Regional Economics: Theory and Practice*, The Free Press, New York, 1970.
- [39] Miernyk, W. H. *The Elements of Input-Output Analysis*, Random House, New York, 1965.
- [40] Myrdal, G. *Economic Theory and Underdeveloped Regions*, Methuen and Company Ltd., University Paperbacks series, London, 1963.
- [41] Needleman, L. (editor). *Regional Analysis*, Penguin Books Australia Ltd., Victoria, 1968.

- [42] Nelson, C.R. *Applied Time Series Analysis for Managerial Forecasting*, Holden-Day Inc., San Francisco, 1973.
- [43] Neville, J.W. *Fiscal Policy in Australia, Theory and Practice*, Cheshire, Melbourne, 1970.
- [44] Norman, M. and Russell, R. *A Tax Forecasting and Simulation Model for the State of Hawaii*, Appendix 14, Vol. 3 of a Program to Introduced Improved Management Methods in Hawaii State Government: A Planning - Budgeting System, Office of the Governor, State of Hawaii, March 1969.
- [45] Hourse, H.O. *Regional Economics*, McGraw-Hill, New York, 1968.
- [46] Perloff, H.S., Dunn, E.S. Jr., Lampard, E.E. and Muth, R.F. *Regions, Resources and Economic Growth*, published for Resources for the Future by the Johns Hopkins Press, Baltimore, 1960.
- [47] Perloff, H.S. and Wingo, L. Jr. (editors) *Issues in Urban Economics*, published for Resources for the Future by the Johns Hopkins Press, Baltimore, 1968.
- [48] Pfouts, R.W. (editor) *Techniques of Urban Economic Analysis*, Chandler Davies, West Trenton, New Jersey, 1960.
- [49] Ralston, A. and Wilf, H.S. (editors) *Mathematical Methods for Digital Computers*, John Wiley and Sons, Inc., New York, 1960.
- [50] Research Seminar in Quantitative Economics, *Econometric Model of Michigan*, Department of Economics, University of Michigan, Ann Arbor, June 1965.
- [51] Richardson, H.W. *Elements of Regional Economics*, Penguin Book Australia Ltd., Victoria, 1969.
- [52] Rock, V.P. (editor) *Policymakers and Model Builders: Cases and Concepts*, Gordon and Breach Inc., New York, 1969.
- [53] Romans, J.T. *Capital Exports and Growth Among U.S. Regions*, Wesleyan University Press, Middletown, Connecticut, 1965.
- [54] Siebert, H. *Regional Economic Growth: Theory and Policy*, International Textbook Company, Seranton, Pennsylvania, 1969.
- [55] Spiegelman, R.G., Baum, E.L. and Talbert, L.E. *Application of Activity Analysis to Regional Development Planning*, U.S. Department of Agriculture, Technical Bulletin, No. 1339, Washington, D.C., 1965.

- [56] Stekler, H.O. *Economic Forecasting*, Praeger Publishers, New York, 1970.
- [57] Theil, H. *Principles of Econometrics*, John Wiley and Sons Inc., New York, 1971.
- [58] ——— *Applied Economic Forecasting*, North-Holland Publishing Company, Amsterdam, 1966.
- [59] Thompson, W.R. *A Preface to Urban Economics*, published for Resources for the Future by the Johns Hopkins Press, Baltimore, 1965.
- [60] Tiebout, C.M. *The Community Economic Base Study*, Supplementary Paper No. 16, Committee for Economic Development, New York, 1962.
- [61] Wilson, T. *Policies for Regional Development*, University of Glasgow Social and Economic Studies, Edinburgh, 1964.
- [62] Wonnacott, R.J. and Wonnacott, T.H. *Econometrics*, John Wiley and Sons, Inc., International Edition, 1970.
- [63] Zarnowitz, V. *An Appraisal of Short-Term Economic Forecasts*, National Bureau of Economic Research, Occasional Paper 104, New York, 1967.

II. Journal Articles, Conference Papers, etc.

- [64] Adler, H.J. "Approaches to Regional Economic Accounting in Canada", *The Review of Income and Wealth*, Vol. 16, 1970, pp. 185-208.
- [65] Alexander, J.W. "The Basic-Nonbasic Concept of Urban Economic Function", *Economic Geography*, Vol. 30, 1954, pp. 246-261.
- [66] Almon, S. "The Distributed Lag between Capital Appropriations and Expenditures", *Econometrica*, Vol. 33, 1965, pp. 178-196.
- [67] ——— "Lags between Investment Decisions and their Causes", *The Review of Economics and Statistics*, Vol. 50, 1968, pp. 193-206.
- [68] Anderson, R.J. Jr. "A Note on Economic Base Studies and Regional Econometric Forecasting Models", *Journal of Regional Science*, Vol. 10, 1970, pp. 325-333.

- [69] Archibald, G.C. "Regional Multiplier Effects in the U.K.", *Oxford Economic Papers*, Vol. 19, 1967, pp. 22-45.
- [70] Artle, R. "External Trade, Industrial Structure, Employment Mix and the Distribution of Incomes: A Simple Model of Planning and Growth", *The Swedish Journal of Economics*, Vol. 67, 1965, pp. 1-23.
- [71] Barnard, J.R. Macmillan, J.A. and Maki, W.R. "Evaluation Models for Regional Development Planning", *Papers and Proceedings of the Regional Science Association*, Vol. 23, 1969, pp. 117-138.
- [72] Bell, F.W. "An Econometric Forecasting Model for a Region", *Journal of Regional Science*, Vol. 7, 1967, pp. 109-128.
- [73] Billings, R.B. "Regional Defense Impact - A Case Study Comparison of Measurement Techniques", *Journal of Regional Science*, Vol. 10, 1970, pp. 199-216.
- [74] Bowden, E.V. "The Theory and the Practice of Regional Development Economics", *Land Economics*, Vol. 47, 1971, pp. 113-121.
- [75] Box, G.E.P. and Pierce, D.A. "Distribution of Residual Autocorrelations in Autoregressive - Integrated Moving Average Time Series Models", *Journal of the American Statistical Association*, Vol. 65, 1970, pp. 1509-1526.
- [76] Brown, A.J. "Surveys of Applied Economics: Regional Economics, with Special Reference to the United Kingdom", *The Economic Journal*, Vol. 79, 1969, pp. 759-796.
- [77] _____ and Woodward, V.H. "Regional Social Accounts for the United Kingdom", *The Review of Income and Wealth*, Vol. 19, 1973, pp. 335-347.
- [78] Brown, R.G. and Meyer, R.G. "The Fundamental Theorem of Exponential Smoothing", *Operations Research*, Vol. 9, 1961, pp. 673-685.
- [79] Burton, R. and Dyckman, J.W. "Defense Expenditure in Forecasts of California's Economic Growth", Symposium: Regional Impact of Defense Expenditures, *Western Economic Journal*, Vol. 3, 1964-65, pp. 133-141.
- [80] Cairncross, A. "Economic Forecasting", *The Economic Journal*, Vol. 79, 1969, pp. 797-812.
- [81] Chambers, J.C. Mullich, S.K. and Smith, D.D. "How to choose the Right Forecasting Technique", *Harvard Business Review*, Vol. 49, July-August, 1971, pp. 45-74.

- [82] Dutta, M. and Su, V. "An Econometric Model of Puerto Rico", *Review of Economic Studies*, Vol. 36, 1969, pp. 319-333.
- [83] Fisher, J. L. "Reflections on the Formulation of Regional Policy", *Papers and Proceedings of the Regional Science Association*, Vol. 18, 1967, pp. 67-74.
- [84] Garnick, D. H. "Differential Regional Multiplier Models", *Journal of Regional Science*, Vol. 10, 1970, pp. 35-47.
- [85] _____ "Disaggregated Basic-Service Models and Regional Input-Output Models in Multiregional Projections", *Journal of Regional Science*, Vol. 9, 1969, pp. 87-99.
- [86] Garrison, C. B. "The Impact of New Industry: An Application of the Economic Base Multiplier to Small Rural Areas", *Land Economics*, Vol. 48, 1972, pp. 329-337.
- [87] Ghali, M. and Renaud, B. "Regional Investment and Regional Growth: Some Empirical Evidence", *The Southern Economic Journal*, Vol. 38, 1971, pp. 219-229.
- [88] Glickman, N. J. "An Econometric Forecasting Model for the Philadelphia Region", *Journal of Regional Science*, Vol. 11, 1971, pp. 15-32.
- [89] Golladay, F. L. and Sandoval, A. D. "Optimal Development Policy in an Open Regional Economy: A Programming Analysis", *Journal of Regional Science*, Vol. 12, 1972, pp. 185-198.
- [90] Graham, R. E. Jr. and Romans, J. T. "Regional Economic Accounting in the U.S. Office of Business Economics - An Appraisal", *The Review of Income and Wealth*, Vol. 17, 1971, pp. 1-59.
- [91] Gramlich, E. M. "State and Local Governments and their Budget Constraint", *International Economic Review*, Vol. 10, 1969, pp. 163-182.
- [92] Green, G. R. "Forecasting State Variables from National Econometric Models", *Growth and Change*, Vol. 3, April, 1972, pp. 36-39.
- [93] Greig, M. A. "Regional Multiplier Effects in the U.K.: A Comment", *Oxford Economic Papers*, Vol. 23, 1971, pp. 277-284.
- [94] Greytak, D. "A Statistical Analysis of Regional Export Estimating Techniques", *Journal of Regional Science*, Vol. 9, 1969, pp. 387-395.

- [95] Griliches, Z. "Distributed Lags: A Survey", *Econometrica*, Vol. 35, 1967, pp. 16-49.
- [96] Hampton, P. "An Econometric Model of the Auckland Provincial District of New Zealand 1923-1939", *New Zealand Economic Papers*, Vol. 5, 1971, pp. 88-99.
- [97] Hansen, W. L. and Tiebout, C. M. "An Intersectoral Flows Analysis of the California Economy", *Review of Economics and Statistics*, Vol. 45, 1963, pp. 409-418.
- [98] Harris, B. "Urban Development Models: New Tools for Planning, Special Issues", *Journal of the American Institute of Planners*, Vol. 31, May, 1965, pp. 90-94.
- [99] Hartman, L. M. and Seckler, D. "Towards the Application of Dynamic Growth Theory to Regions", *Journal of Regional Science*, Vol. 7, 1967, pp. 167-173.
- [100] Hildebrand, G. H. and Mace, A. Jr. "The Employment Multiplier in an Expanding Industrial Market: Los Angeles County, 1940-47", *Review of Economics and Statistics*, Vol. 32, 1950, pp. 241-249.
- [101] Hirsch, W. Z. "An Application of Area Input-Output Analysis", *Papers and Proceedings of the Regional Science Association*, Vol. 5, 1959, pp. 79-92.
- [102] Hultman, C. W. "Exports and Economic Growth: A Survey", *Land Economics*, Vol. 43, 1967, pp. 148-157.
- [103] Ichimura, S. "An Econometric Analysis of Domestic Migration and Regional Economy", *Papers and Proceedings of the Regional Science Association*, Vol. 16, 1966, pp. 67-76.
- [104] Isard, W. and Kuenne, R. E. "The Impact of Steel upon the Greater New York-Philadelphia Industrial Region: A Study in Agglomeration Projection", *Review of Economics and Statistics*, Vol. 35, 1953, pp. 289-301.
- [105] Kendrick, J. W. and Jaycox, C. M. "The Concept and Estimation of Gross State Product", *The Southern Economic Journal*, Vol. 32, 1965, pp. 153-168.
- [106] Kerr, A. and Williamson, R. B. "Regional Economics in the U.S.", *Growth and Change*, Vol. 1, January, 1970, pp. 5-19.

- [107] Klein, L. R. "The Estimation of Distributed Lags", *Econometrica*, Vol. 26, 1958, pp. 553-565.
- [108] ——— "The Specification of Regional Econometric Models", *Papers and Proceedings of the Regional Science Association*, Vol. 23, 1969, pp. 105-115.
- [109] ——— "What Kind of Macroeconometric Model for Developing Economies?", *The Econometric Annual of the Indian Economic Journal*, Vol. 13, 1970, pp. 313-324.
- [110] Kmenta, J. "An Econometric Model of Australia, 1948-61", *Australian Economic Papers*, Vol. 5, 1966, pp. 131-164.
- [111] Lane, T. "The Urban Base Multiplier: An Evaluation of the State of the Art", *Land Economics*, Vol. 42, 1966, pp. 339-347.
- [112] Leabo, D. A. "Stepwise Regression Analysis applied to Regional Economic Research", *Proceedings of the Business and Economic Statistics Section of the American Statistical Association*, 1970, pp. 544-548.
- [113] L'Esperance, W. L., Nestel, G. and Fromm, D. "Gross State Product and an Econometric Model of a State", *Journal of the American Statistical Association*, Vol. 64, 1969, pp. 787-807.
- [114] Leven, C. L. "A Theory of Regional Social Accounting", *Papers and Proceedings of the Regional Science Association*, Vol. 4, 1958, pp. 221-237.
- [115] Mattila, J. M. and Thompson, W. R. "The Measurement of the Economic Base of the Metropolitan Area", *Land Economics*, Vol. 31, 1955, pp. 215-228.
- [116] McColl, G. D. and Throsby, C. D. "Multiple Objective Benefit-Cost Analysis and Regional Development", *The Economic Record*, Vol. 48, 1972, pp. 201-219.
- [117] Meyer, J. R. "Regional Economics: A Survey", *American Economic Review*, Vol. 53, 1963, pp. 20-54.
- [118] Miernyk, W. H. "Long-Range Forecasting with a Regional Input-Output Model", *Western Economic Journal*, Vol. 6, 1968, pp. 165-176.

- [119] Moody, H. T. and Puffer, F. W. "A Cross Regional Product Approach to Regional Model-Building", *Western Economic Journal*, Vol. 7, 1969, pp. 391-402.
- [120] Moore, G. H. "Forecasting Short-Term Economic Change", *Journal of the American Statistical Association*, Vol. 64, 1969, pp. 1-22.
- [121] Naylor, T. H., Seaks, T. G. and Wichern, D. W. "Box-Jenkins Methods: An Alternative to Econometric Models", *International Statistical Review*, Vol. 40, No. 2, 1972, pp. 123-137.
- [122] Nerlove, M. "A Tabular Survey of Macro-Econometric Models", *International Economic Review*, Vol. 7, 1966, pp. 127-175.
- [123] North, D. C. "Location Theory and Regional Economic Growth", *Journal of Political Economy*, Vol. 63, 1955, pp. 243-258.
- [124] Park, S. H. "Least Squares Estimates of the Regional Employment Multiplier: An Appraisal", *Journal of Regional Science*, Vol. 10, 1970, pp. 365-374.
- [125] Phillips, A. W. "The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861-1957", *Economica*, Vol. 25, 1958, pp. 283-299.
- [126] Porwit, K. "Theoretical and Methodological Questions in the Construction of Comprehensive Models for Regional Planning", *Papers and Proceedings of the Regional Science Association*, Vol. 22, 1969, pp. 203-213.
- [127] Pratt, R. T. "Regional Production Inputs and Regional Income Generation", *Journal of Regional Science*, Vol. 7, 1967, pp. 141-149.
- [128] Reiner, T. A. "Economic Planning", *Journal of the American Institute of Planners*, Vol. 32, March, 1966, pp. 115-119.
- [129] Robock, S. H. "Strategies for Regional Economic Development", *Papers and Proceedings of the Regional Science Association*, Vol. 17, 1966, pp. 129-141.
- [130] Sasaki, K. "Military Expenditures and the Employment Multiplier in Hawaii", *Review of Economics and Statistics*, Vol. 45, 1963, pp. 298-304.

- [131] Smith, P. E. "An Econometric Growth Model of the United States", *The American Economic Review*, Vol. 53, 1963, pp. 682-693.
- [132] Solow, R. M. "Technical Change and the Aggregate Production Function", *Review of Economics and Statistics*, Vol. 39, 1957, pp. 312-320.
- [133] Spiegelman, R. G. "On Activity Analyses Models in Regional Development Planning", *Papers and Proceedings of the Regional Science Association*, Vol. 17, 1966, pp. 143-159.
- [134] Spivey, W. A. and Wecker, W. E. "Regional Economic Forecasting: Concepts and Methodology", *Papers and Proceedings of the Regional Science Association*, Vol. 28, 1972, pp. 257-276.
- [135] Steele, D. B. "Regional Multipliers in Great Britain", *Oxford Economic Papers*, Vol. 21, 1969, pp. 268-292.
- [136] Suits, D. B. "Forecasting and Analysis with an Econometric Model", *American Economic Review*, Vol. 52, 1962, pp. 104-132.
- [137] Terry, E. F. "Linear Estimators of the Export Employment Multiplier", *Journal of Regional Science*, Vol. 6, 1965, pp. 17-34.
- [138] Tiebout, C. M. "A Method of determining Incomes and their Variations in Small Regions", *Papers and Proceedings of the Regional Science Association*, Vol. 1, 1955, pp. F1-F12.
- [139] Thomas, M. D. "Regional Economic Growth: Some Conceptual Aspects", *Land Economics*, Vol. 45, 1969, pp. 43-51.
- [140] Thomassen, H. "A Growth Model for A State - Georgia", *The Southern Economic Journal*, Vol. 24, 1957, pp. 123-139.
- [141] Thompson, G. E. "An Investigation of the Local Employment Multiplier", *Review of Economics and Statistics*, Vol. 41, 1959, pp. 61-67.
- [142] Trivedi, P. K. "A Note on the Application of Almon's Method of calculating Distributed Lag Coefficients", *Metroeconomica*, Vol. 22, 1970, pp. 281-286.
- [143] Tsiang, S. C. "A Model of Economic Growth in Rostovian Stages", *Econometrica*, Vol. 32, 1964, pp. 619-648.

- [144] Ulman, E. L. and Dacey, M. F. "The Minimum Requirements Approach to the Urban Economic Base", *Papers and Proceedings of the Regional Science Association*, Vol. 6, 1960, pp. 175-194.
- [145] Vining, R. "Regional Variation in Cyclical Fluctuation viewed as a Frequency Distribution", *Econometrica*, Vol. 13, 1945, pp. 183-213.
- [146] Weiss, S. J. and Gooding, E. C. "Estimation of Differential Employment Multipliers in a Small Regional Economy", *Land Economics*, Vol. 44, 1968, pp. 235-244.
- [147] Wilson, T. "The Regional Multiplier - A Critique", *Oxford Economic Papers*, Vol. 20, 1968, pp. 375-393.
- [148] Zerby, J. A. "An Econometric Model of Monetary Interaction in Australia", *Australian Economic Papers*, Vol. 8, 1969, pp. 154-177.